A Mixed-Method Approach to Develop a Model to Manage the National Strategic Reserve for Critical Intermediate and Final Products in Saudi Arabia

A thesis submitted by

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Declaration

I hereby certify that this material, which I now submit for assessment on the programme of study leading to the award of Doctor of Philosophy, is entirely my own work and that I have exercised reasonable care to ensure that the work is original, and does not to the best of my knowledge breach any law of copyright, and has not been taken from the work of others save and to the extent that such work has been cited and acknowledged within the text of my work.

Signed: **ID No.:** 18213197 **Date:** 06/12/2023

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A Mixed-Method Approach to Develop a Model to Manage the National Strategic Reserve for Critical Intermediate and Final Products in Saudi Arabia

Aiman Fadil

Abstract

In recent years, the idea of "strategic reserve" has become a prominent public policy concern. COVID-19, Brexit, war, and some other similar cases will leave/have left us with a lesson that has impacted the supply chain in almost all product types. Countries have now recognized that some goods cannot be sustained in a situation of uncertainty. This research covers the gap in developing the purchasing portfolio model from an organizational level to a national/country level to manage critical intermediate and final products. Through investigating the relationship between two factors: the casual factor supply risk (independent factor); and the impacted (dependent factors) political, economic, sociocultural, and technological (PEST) factors, this study has a significant contribution to the theoretical, empirical, and practical knowledge in terms of classifying critical intermediate and final products using the principle of Resource Dependency Theory and Portfolio Theory. A mixed-method research approach (exploratory sequential design) was determined to be the most suitable approach in order to fulfil the academic purposes of this exploratory research. The semi-structured interview was conducted with 23 experts in Saudi Arabia that have been selected for the purpose of this study. The qualitative study identified 30 key measurement variables for both factors, in which 19 variables were confirmed using the factor analysis technique. The second phase of this research is quantitative research, where a questionnaire was developed based on the qualitative research results. It was then shared with 152 experts in four critical intermediate and final products in Saudi Arabia to test the model quantitatively resulted a positive significant relationship (.297) between the model's dimensions. A Multidimensional Scale (MDS) technique was used to classify and determine the criticality level of tested products, which resulted in rice as a leveraged product, gasoline as a non-critical product, semiconductors as a strategic product, and insulin as a bottleneck product on a "national level" which was validated by Saudi's experts as the final step in this research. However, it's important to note that the study is limited to one country, Saudi Arabia, and has a relatively small sample size; therefore, a number of future studies have been recommended including the context and study sample size.

Chapter 1: Research Overview

1.1 Introduction

This chapter begins by providing a general background of the research. It introduces the research topic, the research objective, the research question, and the research methodology. The chapter further explores the research gap and the rationale for conducting this subject and concludes with an outline of the chapters contained in this thesis.

1.2 Research Background

In a given country, the strategic reserve entails the establishment of a governmental department responsible for managing the storage of essential goods such as basic foods, water, major medicines, and other strategic products. This is generally in accordance with specific government policies to meet the needs of the country's population. Hashimzade, Myles, & Black (2017) define strategic reserve as a large stock of a product that may be held for use in emergencies such as wars, natural disasters, or to stabilize product prices. The main goal of the strategic reserve is to guarantee the flow and availability of these essential products for people of a certain country over a given period of time. In the absence of the strategic reserve, the governmental management of the country may face an economic crisis that could be followed by political unrest and instability. As such, it plays a significant role during emergencies (He, Wen, Yang, & Song, 2018).

The concept of strategic reserve has been part of the human condition at least since people became sedentary thousands of years ago and started producing food, but probably even earlier than that (van Oyen, 2020). Around 11,000 years ago, people developed systematic large-scale food storage in a way that would have at least served as an essential new buffer against food shortages (Kuijt, Finlayson, 2009). Governments build and maintain strategic reserves for different

products and purposes using a variety of strategies for storage. The USA established a strategic petroleum reserve in 1977 (Zhang, Qin, & Chen, 2017). In 1993, China began planning to build its strategic petroleum reserve on different sites to ensure the flow of supply (H. Li et al., 2017). The Chinese government established a policy related to the amount of food needing to be stored as a strategic reserve to cover demand for at least three months in producer provinces, four to five months in self-balancer provinces, and six months for consumer provinces to prevent the economy incurring damage arising from natural disasters, price fluctuation, etc. (He et al., 2018). To stabilize pork prices for the local market, pork reserve is held in China as well (Gale, Marti, & Hu, 2012). To ensure the flow of supply, the Saudi Arabian government assumes full responsibility for grain sourcing and storage to ensure economic and social stability, using inland silos in different locations (Alamri & Al-Duwais, 2019).

Due to the criticality of these types of products, the strategic reserve has become an essential element for governments to ensure the sustainability and stability of their nation. In 1979, the United States Public Law used the term of strategic and critical for materials that are needed for military and industrial purposes or are essential for civilian needs during emergencies while they are not found or produced in sufficient quantities locally (United States Public Laws, 1979). Therefore, the criticality in this study expresses the importance of the product as it is defined by Roelich et al. (2014, p.380) as "*the product of the probability of an event and the severity of harm resulting from that event*." The term criticality in the context of this research describes the scope of the study in which is the national level, as stated by (Achzet & Helbig, 2013). It focuses on intermediate and final products, which were defined as the products that are eligible to consume by final users or the products that are used as an input or complementary to other products, such

as gasoline and rice, which could be considered both intermediate or final products (Black, Hashimzade, & Myles, 2017; Rutherford, 2005).

A well-known tool in the literature of supply chain management and, more specifically, in the field of purchasing/sourcing is the purchasing portfolio model. Although the purchasing portfolio model has been widely used in the area of procurement, the classifying of critical intermediate and final products that could be used by the final user directly, such as rice, insulin, gasoline, etc., has not been adequately tackled in the literature, leaving an important knowledge gap that needs to be explored. In addition, exploratory research and theoretical frameworks that explain the phenomenon of the strategic reserve and critical intermediate and final products are still few. Study in this area, therefore, needs to be expanded further in a variety of different contexts. Applying the model to the national level would allow further aspects to be added to the purchasing portfolio, which would, in turn, improve the management of the national strategic reserve and our understanding of the model across a variety of contexts.

1.2.1 Research Scope

Purchasing portfolio models have been used widely at the organizational level to manage better the suppliers and resources based on their importance to the company. This research covers the gap in developing the purchasing portfolio model on a national basis to better manage the national strategic reserve for critical intermediate and final products. It investigates the relationship between two factors: the casual factor supply risk (independent factor); and the impacted (dependent factors) political, economic, sociocultural, and technological (PEST) factors in terms of classifying the critical intermediate and final products on the national level. The first step is to

determine the model variables that measure the importance level[1] of the intermediate and final products nationally. The second step is to apply the model by testing critical products, which are: rice, gasoline, semiconductors, and insulin. The study takes place in Saudi Arabia as it offers a good practical investigation where the concept of the strategic reserve is being implemented in several types of products.

1.2.2 Research Objective

The main objective of this research study is to fill a gap in the existing literature, in which, to the best of the researcher's knowledge, no study to date has been designed to:

"Develop a purchasing portfolio model to manage the national strategic reserve for critical intermediate and final products."

Therefore, an important part of this research is dedicated to:

- Identifying the dimensions that help measure the importance level of the intermediate and final products nationally.

- Empirically validating the model by testing the relationship between the study's factors and testing the selected measurement variables using four intermediate and final products.

1.2.3 Research Question

This research aims to answer the following question:

[1] In the context of this study, the term of "importance level" refers to a graded system used to assess and categorize the products being tested based on their relative significance or priority.

"How to determine the criticality level of intermediate and final products that need to be strategically reserved?"

To answer this question, three sub-questions were determined. The first question aims to identify the model variables, and the second question seeks to determine the importance level of the critical intermediate and final products on the national level. The third research question aims to propose strategic recommendations to manage the critical intermediate and final products on the national level.

1.2.4 Research Rationale

During the past two years of writing this thesis, many countries have faced the issue of a lack of one or more of the critical intermediate or final products. The United Kingdom had a problem with the availability of some food and critical health commodities during the Brexit process (Freund & Springmann, 2021; Milne-Ives, Lam, van Velthoven, & Meinert, 2020). During the Russian-Ukrainian war, most Arab countries had an issue with the supply of agricultural products (Welsh, 2022). Most of the world faced a problem when, the government of Indonesia, the biggest palm oil producer restricted the supply of palm oil (Indriyadi, 2022). Around 40% of infant formula supplies were out of stock in the USA (Eshkenazi, 2022). Therefore, it is essential to determine the national needs for intermediate and final products. Identifying the need is the first step in the purchasing process (Bäckstrand, Suurmond, van Raaij, & Chen, 2019). Once the administrative government identifies what exactly is needed, the possibility of shortage occurrence decreases by using one of the possible government tools known as the national strategic reserve (Jones, 2018). Hence, the anticipated result of this research will assist government policymakers and decision-makers in better managing the national strategic reserve. The classification model

will enable decision-makers to precisely determine national requirements. They will be able to identify what type of product should be considered a strategic product and why it is considered as such.

1.3 Research Methodology

An exploratory sequential design of a mixed-method research approach was determined to be the most suitable approach to pursue in order to fulfil the academic purposes of this exploratory research. The semi-structured interview with 23 experts that has been selected purposively was conducted as a qualitative method. They were used to verify the variables of each dimension to add, remove, or edit the variables that are more applicable to measure the importance level of the critical intermediate and final products. The survey was shared with 152 experts in Saudi Arabia in four intermediate and final products, rice, gasoline, semiconductors, and insulin, to test the model quantitatively and determine the criticality level of these products in Saudi Arabia.

1.4 Research Contribution

This research contributes to the theoretical knowledge by understanding and identifying the relationship between the supply risk factor and the PEST factors in terms of identifying the criticality level of intermediate and final products on the national level using the principle of Resource Dependency Theory and Portfolio Theory – purchasing model. Moreover, it contributes to knowledge by empirically applying the purchasing portfolio model in a context that hasn’t been applied before, managing the national strategic reserve on the national level in the Kingdom of Saudi Arabia as a holistic case study using selected intermediate and final products as sub-cases studies. Finally, it has a practical knowledge contribution by recommending guidelines and

strategies to help implement the purchasing portfolio on a national basis and managing critical intermediate and final products.

1.5 Thesis Structure

As shown in Figure 1 below, a slightly modified five-step approach is used to develop and systematically test the proposed classification model. The five-step approach, which aligns with the case study strategy, has been implemented in the field of procurement by Gangurde & Chavan (2016), Gelderman & Mac Donald (2008), Gelderman (2003), Joesbury (2016) in their studies.

Phase (1) Preparation and development

This phase starts with reviewing the literature to identify the gap. It is the basis of this study. Once done, the research objectives of the study become clear. On this basis, the determination of the required information was applicable; the criteria of the participants who can fulfil the purpose of the study, to develop and test the questionnaire; and, finally, to obtain ethical approval to start the collection of the data.

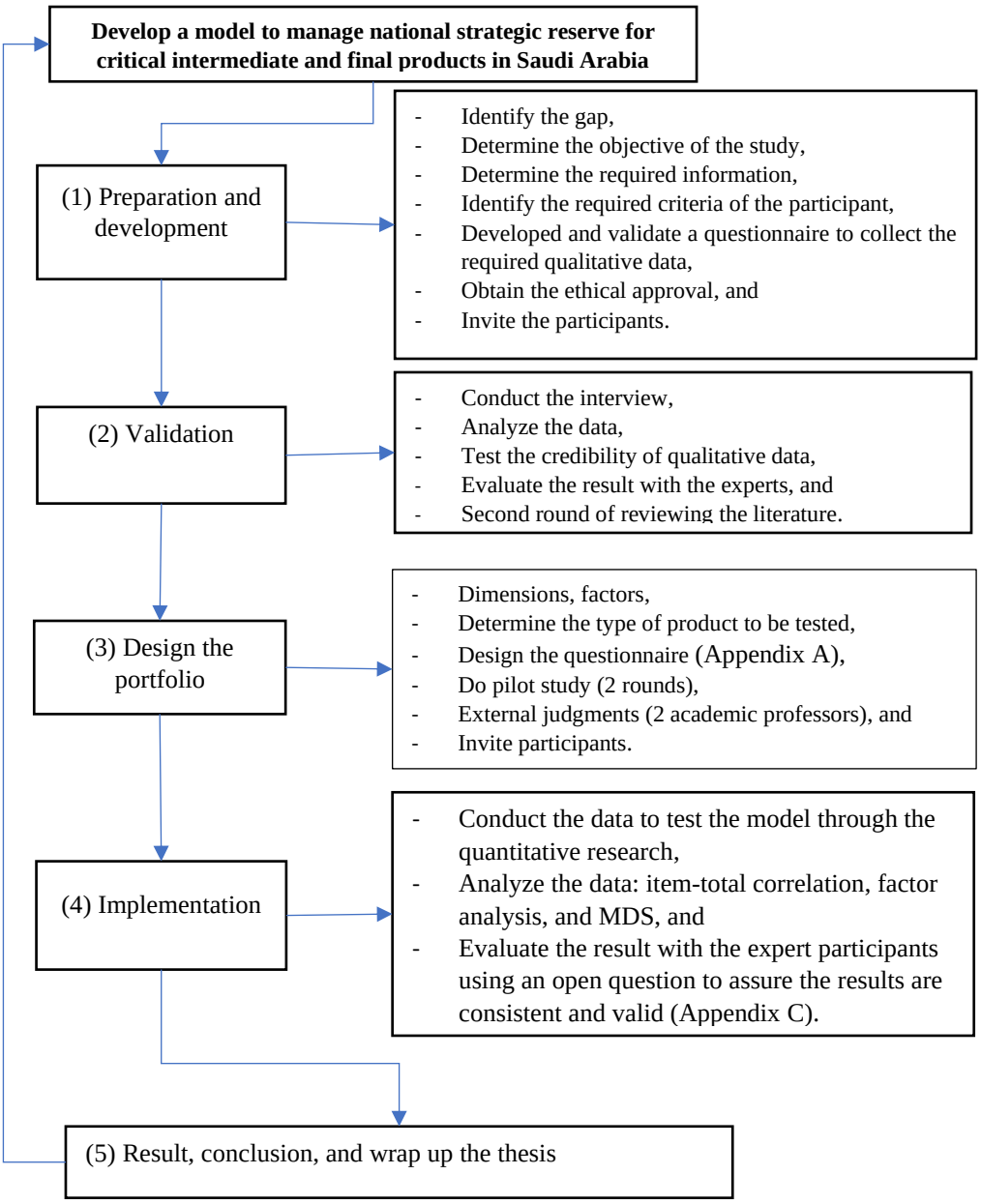

Figure 1: Five Steps Approach (Gangurde & Chavan, 2016; C. Gelderman & Mac Donald, 2008; J. Gelderman, 2003)

Phase (2) Validation

The most significant variables were extracted from reviewing the literature. However, to verify these variables, a semi-structured interview needs to be conducted with an expert who has been selected purposively. At this stage, there are four steps to confirm the model's variables. The first step is to conduct a semi-structured interview to collect the data. The second step is the

analysis of the data. The third step is reviewing the literature as a second round using the final result as a keyword. Before confirming the model variables, the final step is to evaluate the results and verify with the experts the measurement variables for both dimensions, as shown in Figure 2 below. This phase involves two separate interactions with experts to verify the data, prioritize the variables and evaluate the results to confirm the model's variables.

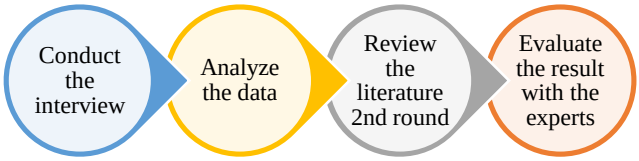

Figure 2: Validation Process

Phase (3) Designing the portfolio

To identify the criticality level of intermediate and final products, the dimension of the matrix and the variables need to be modified from the one that was proposed by Kraljic, profit impact and supply risk. In this study, the PEST and supply risk factors are the two main factors that nationally affect the criticality level of intermediate and final products. The most significant variables were extracted from the literature and interviews with experts who confirmed the final measurement variables. A Likert questionnaire was developed to test the model variables using four intermediate and final products rice, gasoline, semiconductors, and insulin (discussed further in section 3.3.1).

Phase (4) Implementation

To position the product in the model, a survey was shared with experts in the product type and used the variables. In this study, rather than using a subjective method to position the product in the matrix, an objective method (MDS) was used to analyze the product and to determine in which category it was classified. To ensure that the results are consistent and valid, an interview was held with experts as a final judgment follows the examples of Arantes, Alhais, & Ferreira (2022), Ferreira, Arantes, & Kharlamov (2015), D. M. Lee & Drake, (2010), Padhi et al., (2012). Figure 3 below illustrates the process of this phase.

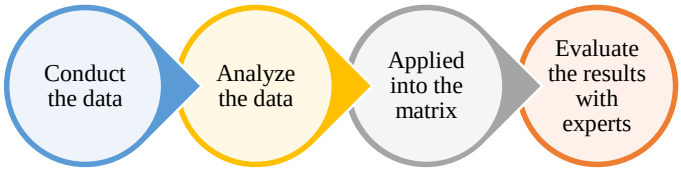

Figure 3: Implementation Process

Phase (5) Result, conclusion, and wrap up the thesis

In the final phase, write up the results that have been used to develop and test the model and wrap up the thesis. Figure 4 provides in-depth detail of the process that was implemented to develop and test the proposed classification model using a five steps approach.

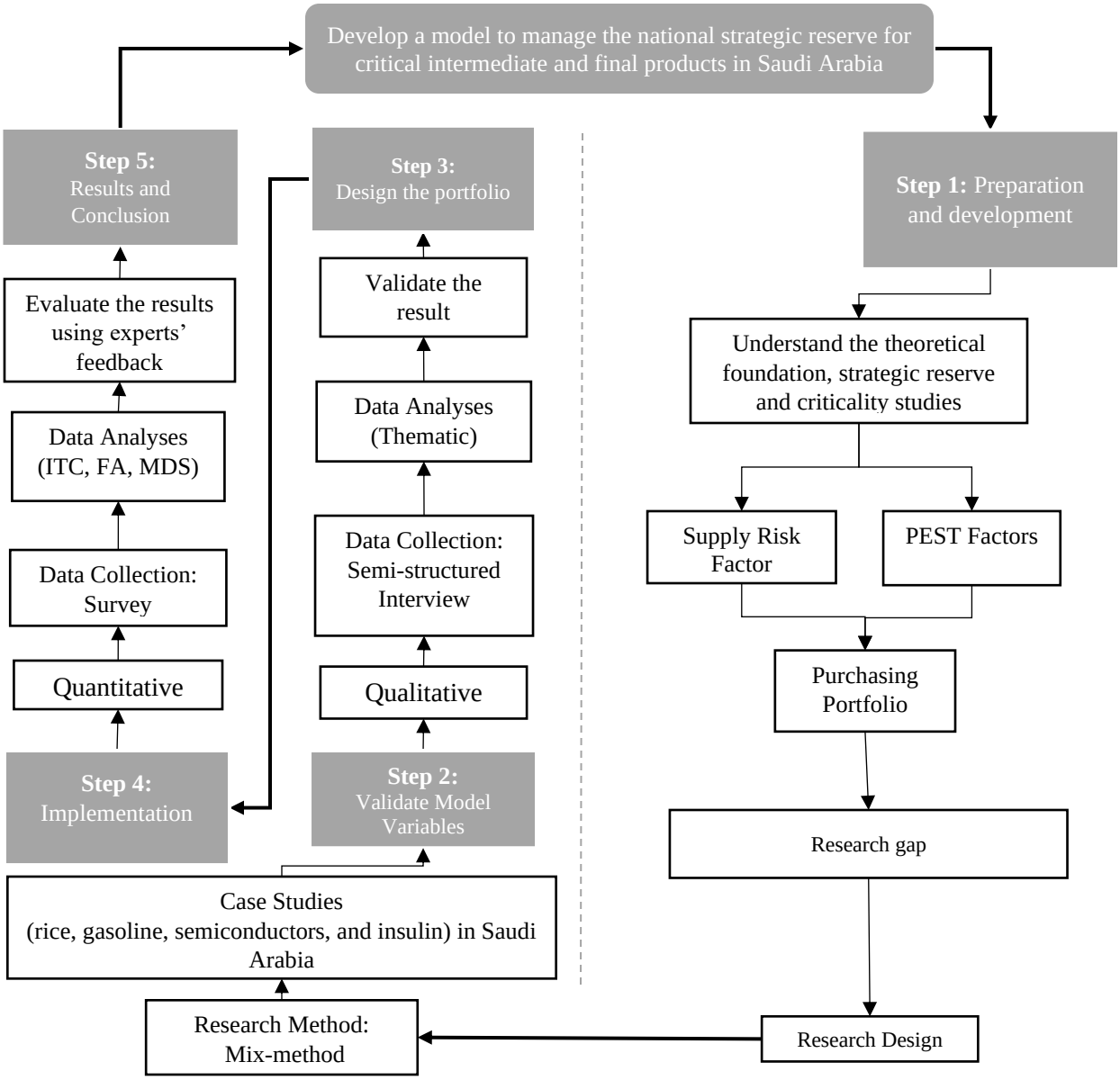

Figure 4: Thesis Structure

This thesis consists of six chapters. The first chapter provides an overview of the research background, context, methodology, and research contribution. Chapter two is the literature review which consists of six sections: the first section after the introduction, discusses the theoretical framework of this research proposing the conceptual framework. The third section discusses the national strategic reserve and the criticality studies to understand the model behind it and the

factors affecting the criticality of the products on a national basis. The fourth and fifth sections of chapter two discuss public procurement and provide a critical review on purchasing portfolio studies with a particular focus on studies that cover the three main elements of developing a portfolio model, which are dimensions, classification, and strategic recommendations. The sixth section provides the conclusion of chapter two, which consists of identifying the research gap and research questions. Chapter three presents the research design, which illustrates the research philosophy that is being implemented in this study and concludes with the ethical procedure for conducting this research. Chapters four and five provide the results of the study for both the qualitative and quantitative methods. Chapter six discusses the result in detail and outlines the study's contribution to advancing the state-of-the-art, the limitations of the research, and recommendations for further study.

Chapter 2: Literature Review

2.1 Introduction

Reliable knowledge is transferable (N. Lee & Lings, 2008). Each field and study has its own history and background; without this crucial information, we would not have the present or future. Future studies build on the current research, which was built on previous studies (Snyder, 2019). This resembles a chain of knowledge that must be followed and considered while understanding the background of the topic being studied. With the rapid knowledge production that we enjoy in today's connected world, it is crucial to follow scientific guidelines to ensure that researchers conduct a review of the topic being researched (Machi & McEvoy, 2012; Snyder, 2019). One of the key elements that keep knowledge growing and improving is a literature review (Snyder, 2019). This is an effective scientific research method that can describe and synthesise previous studies, ultimately advancing knowledge (Ferrari, 2015; Snyder, 2019). Machi and McEvoy (2012, p. 4) define the literature review as "a written document that presents a logically argued case founded on a comprehensive understanding of the current state of knowledge about a topic of study. This case establishes a convincing thesis to answer the study's question".

This study aims to develop a model that helps to identify the critical intermediate and final products to better manage the national strategic reserve. Through this literature review, the aim is to answer the main research question: *How to determine the criticality level of intermediate and final products that need to be strategically reserved?* This is achieved by approaching three sub-questions: "*What are the most significant variables that determine the criticality level of intermediate and final products on a national level?"* In addition, in order to confirm the possibility of classifying major products using the purchasing portfolio model, an empirical

question aims to test the criticality level of four products through the following question, "*Based on the concept of a purchasing portfolio, on a national basis how critical are rice, gasoline, semiconductors, and insulin in Saudi Arabia?"* The third question seeks to provide a practical answer to manage the critical intermediate and final products on a national basis through the following question*, "What are the key strategic recommendations that could be considered by policymakers to manage critical intermediate and final products on a national level in Saudi Arabia?"*

There are different types of literature reviews (Snyder, 2019). The three most common approaches are the narrative literature review, the systematic literature review, and the integrative literature review (Snyder, 2019). Due to the nature of this research, the narrative approach is implemented for this study. This is a comprehensive critical analysis that aims to scientifically analyse the currently available knowledge about the topic, which is considered in different fields and disciplines in order to answer the research question (Snyder, 2019; Wong, Greenhalgh, Westhorp, Buckingham, & Pawson, 2013). To ensure the quality of the literature review, the following steps were implemented, as recommended by Ferrari (2015) and Snyder (2019):

1. **Designing the review** it is crucial to determine the search strategy and how to identify the research gap and questions that need to be answered. To identify the relevant studies, the keywords, phrases, and questions (e.g., national strategic reserve, purchasing portfolio, Kraljic matrix, criticality, food security, etc.) were employed in the searches of accessible and available databases, such as DCU Library and Google Scholar. These were the year of publication, author, publisher, type of publication (e.g., book, article, thesis), and the language.

2. **Inclusion and exclusion criteria** it's essential to use criteria for the selection and filtering of the relevant studies. At this point of the research, the abstract and research findings were read before deciding to read the full article or exclude it. To manage and document the relevant studies, an Excel sheet was developed consisting of the name(s) of the author(s), the title of the research, the date of publishing, the publisher, the scope of the study, and how and where it fits into the current research.
3. **Analysis** of the collected articles that were most relevant to the study and could help to answer the research question and identify the research gap was identified by the researcher.
4. **Structuring and writing the literature review** as shown in Figure 5. The chapter begins with an overview of Resource Dependency Theory (RDT) and Portfolio Theory (PT), which sit at the base of the study. Subsequently, an overview of studies related to strategic reserve and criticality studies to define and extract the variables that could affect the critical intermediate and final products at the national level. It looks then at studies related to public procurement, which includes purchasing portfolio models. The focus then moves to the relevant studies, with a critical analysis on research that has implemented the chosen model, i.e., a purchasing portfolio, in the same classification manner as this research.

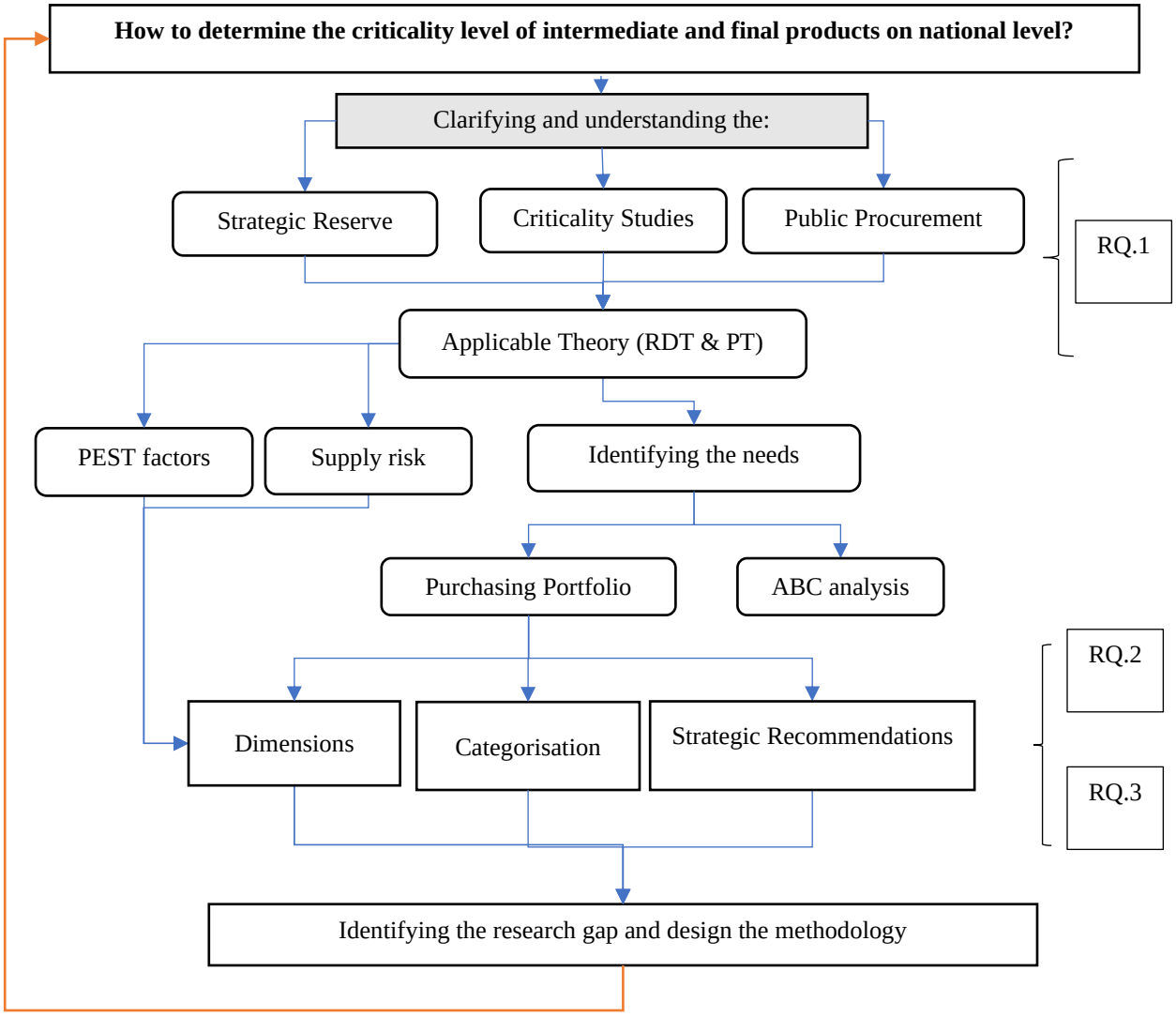

Figure 5: Literature Framework (1/2)

2.2 Theoretical Foundation

In the field of purchasing and supply management, theories are important for both researchers and practitioners as they guide them to develop appropriate frameworks for analysis and to provide clear explanations (Giunipero & Eltantawy, 2022). This section discusses the supported main theories of this research, the Resource Dependency Theory and the Theory of Portfolio, along with other theories that have potential relevance for this research.

2.2.1 Resource Dependency Theory (RDT)

A theory is a set of propositions about the phenomenon being studied (Dul & Hak, 2008). It is characterised by four elements: the object of the study, the concept (theory variable), the propositions that illustrate the causal relations between concepts, and the domain (Dul & Hak, 2008). This research is based on the Resource Dependency Theory. This theory was proposed by Pfeffer and Salancik in 1978 (Alkhuzaim, Kouhizadeh, & Sarkis, 2022; Pfeffer & Salancik, 1978). The theory discusses how resource acquisition can influence an organisation's behaviour and create dependencies that may or may not be beneficial. If the supplier of required materials is available and can be assured, there is no risk to an organisation as long as the structure of the market remains the same. However, problems arise when the surrounding environment is not dependable. If suppliers of the required resource become fewer or scarce, the risk of being unable to obtain the required critical products rises. Pfeffer and Salancik (1978) defined resource dependence as the product of the importance of a given input or output to the organisation and the extent to which it is controlled by the external environment.

Self-sufficiency does not mean that organisations isolate themselves from the surrounding environment. In order to continue to provide what an organisation needs, an external group may demand a certain action from the organisation in return, an action that the group requires in order to survive (Pfeffer & Salancik, 1978). An interdependent relationship exists whenever one actor does not entirely control all the conditions necessary for the achievement of an action or for obtaining the desired outcome from the action. Therefore, survival occurs when an organisation adjusts to and copes with its environment.

Qualified personnel, raw materials, equipment, technology, and more represent the resources that organisations need in order to convert their input into a final useable output. However, organisations are not the only entities to seek these resources. Some resources are required at the national level. For instance, a shortage of qualified personnel or a lack of the technology required to produce insulin or oil is considered to be a threat that affects the flow of supply at the national level, which in turn impacts the nation (Malatino, 2008). Therefore, interdependent relationships between organisations and countries are required due to the uneven distribution of the required resources. A country cannot isolate itself from the rest of the world; even if it achieves self-sufficiency, it is still part of the world.

Uncertainty is the most commonly used term to describe the external environment, shaping the relationship between social actors. It refers to the degree to which future status of the world cannot be anticipated or accurately predicted. It is determined by an organisation's level of forecasting capability at a given point in time; as the accuracy of forecasting techniques improves, uncertainty diminishes. Three structural elements describe the external environment (Alkhuzaim et al., 2022; Pfeffer & Salancik, 1978):

- **Concentration** refers to the ownership of critical resources by a limited number of organizations, entities, or countries, reflecting the balance of power distribution in a given environment.
- **Munificence** refers to the availability or scarcity of critical resources and their feasible alternatives in the external environment, shaping power and dependence.
- **Interconnectedness** is the number and pattern of linkages or connections between organisations as well as the government's institutions that shape the operational behaviour of organisations.

These elements determine the levels of conflict and interdependence, which are reflected in the level of uncertainty experienced by the organisation. Due to uncertainty, the strategic reserve becomes essential (Alkhuzaim et al., 2022), and the more unstable the sources of supply, the larger the inventory must be (Pfeffer & Salancik, 1978). A key element here is the power between the parties in the product supply chain, i.e., who owns and controls the power (Alkhuzaim et al., 2022). It is, therefore, critical to manage this dependence. There are four quadrants in the RDT model, comprised of four possible levels of interdependence and dependence (C. Gelderman, 2022):

- The strategic quadrant refers to high mutual dependence.
- The bottleneck quadrant refers to high supplier dependence (supplier-dominated).
- The leverage quadrant refers to low supplier dependence (buyer-dominated).
- The non-critical quadrant refers to low mutual dependence.

The literature shows a broad range of studies dealing with interdependence and uncertainty, using RDT on its own as a theoretical basis for the research or RDT integrated with other theories to provide a holistic theoretical foundation (Alkhuzaim et al., 2022). This approach was adopted based on the objective of this research. As stated earlier, this study aims to determine the importance of certain products at the national level. In order to assess critical products, two main dimensions are identified by the RDT. The external environment represents the independent factors, and the dependent factors are the internal factors. The independent factor in this study is the supply risk factor, whereas the dependent factors are the political, economic, sociocultural, and technology (PEST) factors.

Due to the criticality of natural resources and their increasing consumption, resources become a concern if the organisation’s survival relies on the availability of scarce resources. In

2011, Tashman introduced the Natural Resource Dependency Theory (NRDT) as a theoretical framework to address this phenomenon (Alkhuzaim et al., 2022; Tashman, 2011). As Tashman (2011) described, the NRDT stands on the organisational ecosystem dependence, which refers to how much an organisation relies on the larger ecological system, such as the natural resources or social and economic systems. According to that, it consists of two main factors: the impact of the environmental system on organisations, which determines the impact on the organisation's operations of difficulties obtaining the required natural resources; on the other hand, the impact of the organisation on the ecosystem, which refers to the extent to which an organisation impacts the ecosystem that it operates in – this can be positive or negative (Alkhuzaim et al., 2022).

2.2.2 Portfolio Theory (PT)

The concept of a portfolio matrix plays a significant role in different fields in shaping an organisation's future strategy as it directs managers and decision-makers to appropriate strategic plans. The concept of a portfolio was first developed by Harry Markowitz in 1950. The framework of Markowitz's model is used to manage risk in finance and investment. The model's primary purpose is to maximise the return on investment with a given level of risk. Subsequently, the model is based on two dimensions, essentially investors' concerns about risk and the expected return (Markowitz, 2009).

Soon after this theory was published, in 1957, Ignore Ansoff developed the Ansoff matrix. This marketing framework enables companies to identify and evaluate their growth opportunities based on their products and market within four marketing strategies. The market penetration strategy aims to increase a company's market share by selling more of its existing products to its existing customers, while the market development strategy seeks to create a new market segment

by selling its existing products to new customers. By contrast, the product development strategy is where a company offers a new product to its existing customers, and the final strategy is diversification, where the company develops a new product for a new market segment (Khajezadeh et al., 2019; Meldrum & McDonald, 1995).

In 1963, the Boston Consulting Group (BCG) introduced their well-known matrix model, which evaluates the market based on its growth rate and a company's relative market share in order to identify which products or services to companies should invest in, maintain, optimise, or opt out of. The matrix typically has four quadrants (Khajezadeh et al., 2019; Udo-Imeh, Edet, & Anani, 2012):

1. The stars quadrant indicates that a product or service is high in both market share and growth. Therefore, more investment is required in order for a company to maintain or increase its market share.
2. The cash cows quadrant indicates that a product has a high level of market share with low growth in the market. Due to the low-growth market, it is advisable to minimise investment in the product as it is generating profit at this stage.
3. The question marks quadrant, which, unlike the cash cow, requires more product investment to increase the company's market share and push the product to become a star product.
4. The dogs quadrant, which includes products that have both low market share and low growth. At this stage, it is recommended that divestment is considered.

In the 1970s, McKinsey and Company, in collaboration with General Electric (GE), developed a model that aimed to evaluate products by adding two different factors to the BCG

model: industry attractiveness and business unit strength. The attractiveness of the industry includes variables such as market size and growth, profitability, competition, and market policy and procedures. On the other hand, the strength of a business unit consists of market share, brand position, production efficiency, and R&D capability. GE McKinsey's matrix consists of nine quadrants divided into three categories – low, medium, and high. Each of these has its own strategy and recommendation. If a product falls into a high quadrant, it requires more investment, or it should be withdrawn if it falls into a lower quadrant (Didia & Ateke, 2017; Udo-Imeh et al., 2012).

In the same decade, the 1970s, the multinational oil company Shell introduced the Shell directional policy matrix to evaluate and prioritise their own investment opportunities. The model's factors are similar to those of the GE McKinsey model. They are divided into two dimensions and four quadrants, labelled as follows (Udo-Imeh et al., 2012):

1. Grow/Invest: this reflects the attractiveness and strength of an industry where the company should invest and grow its business.
2. Selectivity/Maintain: in this quadrant, the industry is attractive, but the company's business position is weak. Therefore, Shell should select which industry to invest in and focus on maintaining its current position.
3. Harvest/Divest: in this quadrant, Shell has a strong business position, but the industry is not attractive in terms of growth or profitability. At this stage, Shell should harvest its investments in this industry and divest its assets over time.
4. Exit/Divest: any industry classified in this quadrant is unattractive, and Shell has a weak business position there. Based on the model's recommendation, Shell should exit this industry and divest its assets as soon as possible.

The concept of a portfolio matrix is not exclusive to the fields of finance, marketing, or purchasing (discussed in section 2.5). In human resources, the model has been used to classify employees based on their potential and performance, which helps companies to identify their high-potential employees and position them accordingly (Lukovac, Pamučar, Popović, & Đorović, 2017). Fadrian and Arifin (2018) utilised the BCG matrix to manage projects related to information technology (IT), in particular, to analyse the sustainability of 2G technology in the Indonesian market, where 4G changed customer behaviour in terms of data access to social media, and messenger and transportation services. The study reveals that 2G technology has a low market share and experiences low growth rates (Dogs quadrant), which means that its focus on voice services is in the declining phase of the product life cycle. Kołodziejczyk, Mielcarz, and Osiichuk (2019) proposed the Real Estate Portfolio Analysis Matrix based on potential increases in value over the holding period and the ability to generate stable positive cash flows. The model provided four strategic actions for investors in order to optimise their sales strategy based on a property's position in the matrix.

In the field of purchasing, the portfolio theory has become an essential tool used to manage and reduce risk and optimise returns (C. Gelderman, 2022). It is considered as best practice to use this theory to determine strategic products (Irfanto, Maisarah, & Abduh, 2019), and it is one of the most effective and efficient purchasing models being used by academics and practitioners to analyse purchasing strategy (Rachman, 2019). The portfolio has been applied in cases where there are high levels of supply and logistical difficulties and risks. It is applied in major industries that require a high level of quality and productivity, such as the aircraft and petrochemical industries. The classification phase of the model has therefore been proven to be reliable and credible for identifying and classifying required raw materials, products, and different items in different cases

and situations. As such, it provides direction to decision-makers on how to achieve optimal management. In 1983, Peter Kraljic provided a purchasing framework at the time of writing this thesis was still considered to be one of the most powerful tools in the field. Figure 6 summarises the framework, and it can be found in C. Gelderman (2022) in his recently published chapter on portfolio theory.

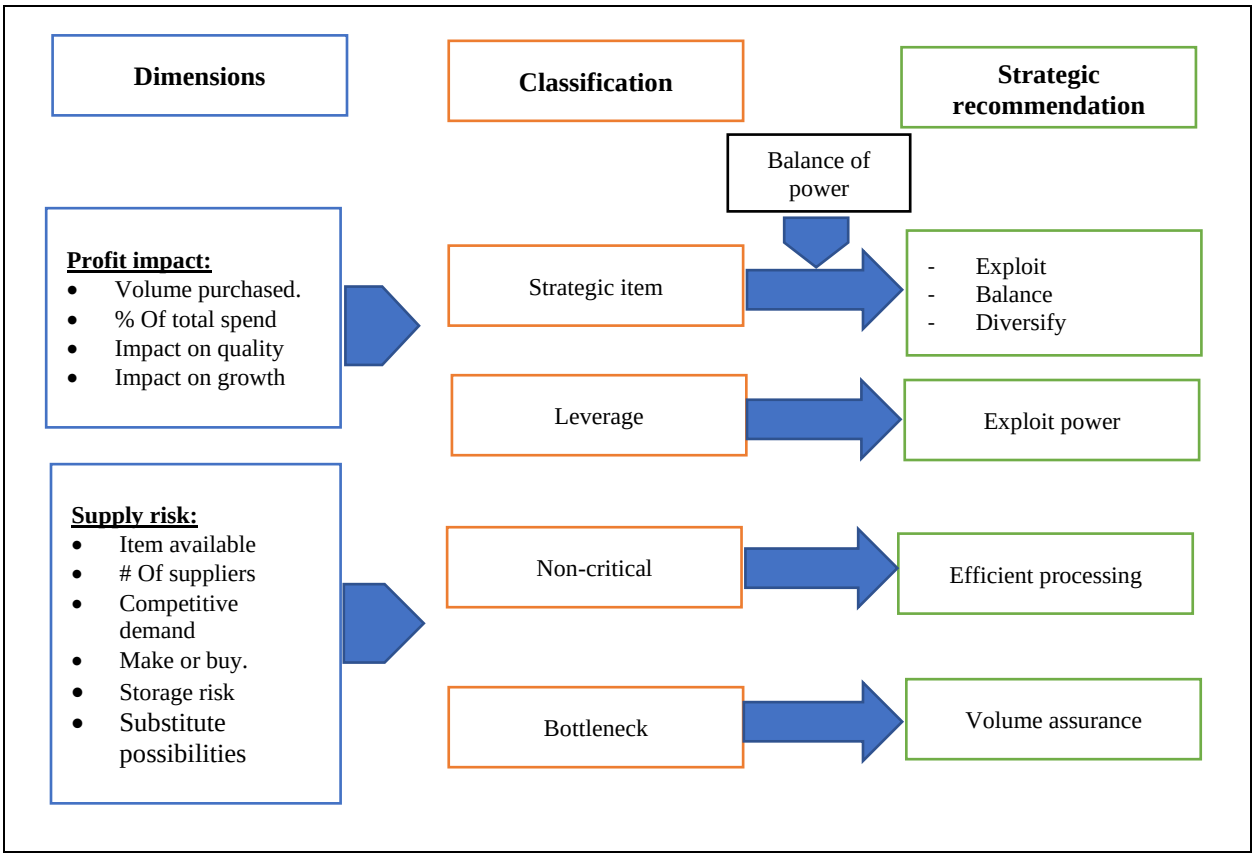

Figure 6: Kraljic Purchasing Portfolio Framework Summary - Adopted from (C. Gelderman, 2022, p. 478)

On this basis, in addition to the resource dependency theory, the purchasing portfolio has been selected as a model to help fulfil the purpose of this study. Although it has been used in several different scenarios, to the best of the author's knowledge, it has not been used before now to classify strategic products on a national basis to manage the national strategic reserve, indicating a research gap. In addition, the PEST analysis model has been combined with other models, such

as SWOT analysis and Porter's five forces model (Sammut-Bonnici & Galea, 2015). To the best of the author's knowledge, to date, no studies have been published that combine the purchasing portfolio and PEST factors to determine the criticality level of intermediate and final products on a national level, making this study unique.

I Conceptual Framework

Based on the Resource Dependency Theory and Portfolio Theory, the conceptual framework of this research was developed, as shown in Figure 7. Holding the national strategic reserve for critical products is essential to assure the stability and growth of the nation. Through the classification model, decision-makers will be able to manage the national strategic reserve better.

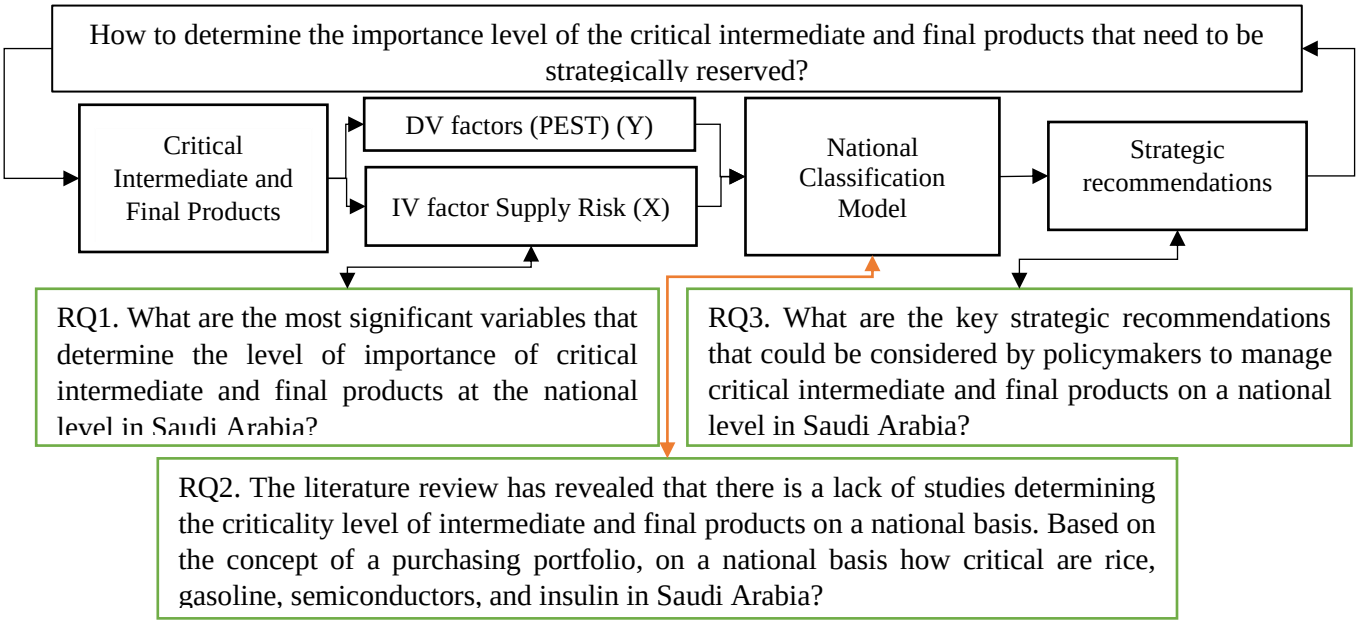

Figure 7: Conceptual Framework

2.2.3 Relevant Theories

The purchasing portfolio model contains four different quadrants. Each of these has its own strategy and level of criticality that the management of products, items, or suppliers can be based on. Both the resource dependency theory and the portfolio theory have been used to construct the framework of this research, as illustrated earlier. However, there are some theories that have a potential intervention with the proposed model, such as the resource-based view (RBV), the natural resource-based view (NRBV), the social resource-based view (SRBV), and the resource advantage theory (R-A).

The RBV was proposed by Barne (1991). It is based on which items or products are available internally to the company and are considered critical and valuable by other organisations or nations (Bals & Rosca, 2022; Barney, 1991), unlike the focus of the RDT. According to the RBV, an organisation treats these products or items as a strategic resource and tries to take advantage of their abundance. However, for a resource to be considered a strategic resource, Baney identifies four different criteria that it must fulfil (Bals & Rosca, 2022). The resource must be valuable, rare, un-substitutable, and have limited mobility (Bals & Rosca, 2022). This includes physical assets, financial assets, skills, and the internal environment of the organisation (Bals & Rosca, 2022, P. 108).

Due to environmental and global inequality concerns, two notable theories based on the RBV have been developed: the natural resource-based view theory (NRBV) (Bals & Rosca, 2022; Hart, 1995) and the social resource-based view (SRBV) theory (Bals & Rosca, 2022; Silva & Bitencourt, 2017). The RBV does not take into account the natural environment; therefore, in 1995, Harrt proposed the NRBV (Bals & Rosca, 2022; Hart, 1995). The theory has an economic root as

it assumes that organisations in a country that has an abundance of some critical natural resources such as oil and minerals have a competitive advantage over other organisations in different parts of the world, as they can more easily access these resources (Bals & Rosca, 2022). In addition to the resources considered in the RBV, the NRBV focuses on how organisations act towards the environment in terms of policy and procedures, either to procure or produce items (Bals & Rosca, 2022). It includes pollution prevention, product stewardship, and sustainable development (Kalaitzi, 2016). The theory discusses the importance of the government managing these resources through policy and regulation and investing in education and technology to develop the required skills. As an extension to that, the SRBV was proposed; it highlights the resources and capabilities required to create social, environmental, and economic value (Bals & Rosca, 2022, P. 106). It goes beyond the RBV and NRBV theories as it encourages organisations to utilise their resources to serve the society that it belongs to (Bals & Rosca, 2022). However, this study aims to identify scarce and not readily available products, as is the case with the RBV and its branches.

Finally, a strategic theory complementary to the RBV is the resource-advantage (R-A) theory, which focuses on how organisations can gain and leverage a sustainable competitive advantage over their rivals through resources (Davis & McCarthy-Byrne, 2022). It was introduced in the 1990s in a series of articles by Shelby Hunt and Robert Morgan during the period 1995–1997 (Davis & McCarthy-Byrne, 2022). According to the theory, organisational resources can be categorised into four main types: tangible resources (e.g., building, equipment, and inventory); intangible resources (e.g., brand name and reputation, relationships with suppliers, customers, and competitors); human resources (e.g., an organisation’s expertise, knowledge, and skills), and financial resources (e.g., cash reserves and credit) (Davis & McCarthy-Byrne, 2022). Similar to

the RBV, it has an internal perspective; therefore, it is not aligned with the objective of this research.

2.3 National Strategic Reserve

Strategic reserve can be defined as a large stock of a product that may be held for use during emergencies, such as wheat and tin. It may also be held to stabilize product prices (Hashimzade et al., 2017). As such, it is an economic tool that can be used to stabilize investments in a particular industry and give substantive investment incentives (Jones, 2018). The strategic reserve represents an effective source for a population that might be reliant on these resources during an emergency (Need & Mothershead, 2006). Therefore, the strategic reserve is a key component of a nation becoming more resilient and responsive to unexpected issues that might occur by creating redundancy while supporting local industries and producers (Sampson, 2010). Thus, it represents an important strategy to become more resilient as it enables continuous of operation while solving the issues that cause the disruption of supply (F. Liu et al., 2016). It is a national repository consisting of various medications, vaccines, and medical equipment to supply public health agencies in case of an emergency that might affect the flow of supply and threat the public (Malatino, 2008). To prevent harm to human lives and to ensure sustainable growth, governments in most countries seek to anticipate and prepare for unexpected supply issues that could harm society (Heckmann, Comes, & Nickel, 2015). It thus is a critical component for governments seeking to develop a stronger and more resilient system (Sampson, 2010). Table 1 presents other terms from the literature related to strategic reserve. While they contain the same concept with the same purpose, the terms might be changed based on the objective. The most common terms used in this context are “stockpile,” “national strategic reserve,” “strategic safety stock,” and “buffer stock.”

Table 1: Relevant Strategic Reserve Terms

Stockpile	
Ensuring enough items or equipment is readily available by storing a large quantity of these items or equipment.	(Gorse, Johnston, & Pritchard, 2020)
A large amount of strategic stock of materials, food, etc., built up by a government in anticipation of a war, a break in trading relations with a supplier nation, etc.	(J. Law, 2016)
An organization holds a large stock of raw materials in case of a shortage or any other supply interruption scenarios.	
A reserve set aside for future utilization or a specific objective.	(Park & Allaby, 2017)
A large stock of goods or materials is held primarily for use during a shortage or other emergencies.	(Stevenson, 2010)
Strategic National Stockpile	
The primary reserve of crucial pharmaceutical and medical supplies holds lifesaving stock that can potentially be used during periods of large public health crises, causing a depletion of local resources.	(Porta & Last, 2018)
Strategic Safety Stock	
It consists of five major categories that cover three motivation purposes transaction, safety, and speculative: **Safety stock**: The expected inventory just before the next order arrives, which is induced by the uncertainty of such problem components like demand, processing time, and quantity. **Cycle stock:** It's a standby inventory between different levels of processes. **Pipeline stock:** Concerns about the processing time. It includes all material that is in process and material that is transported and in transit to another processing unit. **Speculative stock:** Concerns more about controlling prices, whether to buy or sell required items. **Anticipation stock:** A seasonal phenomenon. In which an inventory is held to cope with peak demand.	(Minner, 2000)
Strategic Storage	
"At a basic level, storage provides food for tomorrow, seed corn for the next year, and fodder for animals, so that people can reproduce themselves and their family store what they think they need to live their lives."	(van Oyen, 2020, p.10)
Social Storage	
A levelling mechanism between society during a crisis period or lack of product.	(Dirks et al., 1980)
Buffer Stock	

Table 1 (continued)

A supply of a product held by an organization to avoid potential market disruption or to control the market price.	(Moles & Terry, 1996)

2.3.1 Strategic Reserve Studies

An item may be controlled through a national strategic reserve, not because it is a product but because it is an essential ingredient/input in producing a product. For example, there are no alternatives to the use of phosphorus as it cannot be manufactured; there is a need to have a strategic reserve for this type of element. K. Law & Krishna (2020) justified the economic importance of recovering phosphorus from wastewater and building a strategic phosphorus reserve by centralizing the mono-incineration to extract phosphorus. The reasons for this include the limited natural resources in the USA and the importance of this type of element since, without it, no other major products such as grain, wheat, or food can be produced (K. Law & Krishna, 2020). The study illustrated the importance of having a strategic reserve for this type of element due to the national shortage and, at the same time, the high level of demand as it has an impact on the availability of other major products. However, this research investigates the criteria for determining the importance level of intermediate and final products at the national level in order to ensure the availability of these types of products by strategically securing the flow of supply.

As a case in point, consumption behavior in China is another example of the forces that can drive countries to identify the importance of certain products at a national level (Gale et al., 2012). Since more than half the world's pork is consumed by Chinese people, it represents an important element of China's economy. Since the central government is sensitive to domestic instability, it created pork reserves in 2007 to stabilize live hog prices at the same time as protecting local farmers from price instability. In Egypt, such shortages increased food prices, which

contributed to a revolution known as Arab Spring in 2011 (Breisinger et al., 2014). As a consequence, the revolution led to the overthrow President Hosni Mubarak, who had been in power for almost 30 years (Shehata, 2011). Food shortages have led to famine in Yemen and Somalia (Breisinger et al., 2014). Although the Yemen are suffering from food shortages, they use most of their land and resources to farm Qat "type of tobacco," instead of grains; 85% of men and 60% of women use Qat daily (Ward & Gatter, 2000). It is considered an important part of the culture and social fabric as the absence will lead to a significant impact on society and the economy (Ward & Gatter, 2000; Wedeen, 2007).

Health emergencies, such as disasters and disease outbreaks, has an impact on the supply flow (Iyengar, Hedman, Forte, & Hill, 2016). Policy and procedure changes, for example, recommended clinical practices, can dramatically impact availability; incomplete or delayed regulatory submissions may delay marketing authorization and potentially lead to national supply shortages, poor financial incentives for manufacturers, changes in reimbursement, changes in regulatory requirements, and costs required to correct manufacturing errors affect the availability of medicines (Iyengar et al., 2016). Consequently, shortages in major medicines lead to increased costs for health systems. For example, the additional labor cost of responding to shortages increases the prices of other substitute medicines, as well as the costs of treating adverse reactions, medication errors, and consequences of delayed therapy (Iyengar et al., 2016). Therefore, modern states use strategic reserves as a tool to keep medical product prices manageable (van Oyen, 2020).

The world suffered from the global Covid-19 pandemic due to the unavailability of a vaccine (WHO, 2020). The report published by the United Nations indicates the impact of Covid-19 on the Arab region during the absence of a vaccine. As a result, the employment rate will be affected, the prices of most products will increase, while the total income of most of the middle

class will decrease. The attitude of society is also impacted due to the lack of income, food, and services (ESCWA, 2020). At this stage, people's behavior may become more aggressive toward each other as they struggle to survive and compete for resources (Goszczynska, Tyszka, & Slovic, 1991). Therefore, governments need to create an enabling environment for their nations to become more resilient and absorb shocks. One thing can be achieved is through holding a strategic reserve for the required products (Fan, Pandya-Lorch, Yosef, Fritschel, & Zseleczky, 2014), which aims to stabilize and manage future behavior variables such as imports, prices, production, level of dependency, and GDP (Anser, Abbas, Chaudhry, & Khan, 2020).

Increases in food prices have increased the risk of political stability (Breisinger et al., 2014). For instance, the 2007–2008 global food crisis sparked rioting in 48 countries, while food insecurity at the national and household levels is a major cause of conflict in some countries. This supports the point of view that food shortage was one of the crucial causes of the "Arab awakening," as the majority of the impacted countries are net food consumers (Breisinger et al., 2014). Therefore, many governments have expanded consumer subsidies in response to high product prices and popular uprisings. However, the capacity of the government to shore up safety net programs against high food prices differs between countries; for example, the Gulf Cooperation Council (GCC) has ample budgetary resources to absorb higher costs, even though they are entirely dependent on international markets for their wheat. In fact, rising food prices will be offset by rising export revenue because of the positive correlation between energy and food prices (Larson, Lampietti, Gouel, Cafiero, & Roberts, 2014).

A previous study has tried to take advantage of having the strategic reserve control the market price (Cole, Haarsma, & Snoeyink, 1986), in which the authors look at the problem of managing the strategic reserve from a financial point of view. The study developed a mathematical

model that explains when metal cobalt is to be bought and sold. The model's strength is that it is quite general and can be applied to different types of products. However, one of the problems is that the long-term price for some types of products is difficult to predict (Hertel, Baldos, & van Der Mensbrugghe, 2016; Weng et al., 2019).

The oil market is subject to a number of factors that threaten the flow of supply, which include but are not limited to political instability, wars, natural disasters, cartel action, price increases, and possible decreases in the output and employment of an oil-consuming country (X. B. Zhang et al., 2017). To identify the safest global petroleum suppliers (Guo, Hao, & Niu, 2020), the following criteria to measure the supply risk factor can be applied: the capacity of the supplier, the stability of the supply process, the buyer-supplier relationship, the capacity of the supplier of the exporting country, and the national risk level. The most recent study concludes that Saudi Arabia and Russia were the countries least vulnerable to petroleum supply fluctuations between 2000–2016 (Guo et al., 2020). Only a pipeline is used to move oil from Russia to China, which contains a risk due to the geographical factor; in contrast, Saudi Arabia uses shipping to deliver the oil through several nodes[2]. These nodes have been used to measure the supply risk factor. For example, in importing from Saudi Arabia to China, the risk nodes are the Persian Gulf, Arabian Sea, Indian Ocean, Malacca Strait, and South China Sea, whereas, for China to obtain its oil from Russia, the risk node is that of pipeline transportation. Each of these nodes contains a measurement factor to evaluate the risk.

Supply and demand play a significant role in determining the price of the critical products. In 1973, oil production cutbacks took place as a result of deliberate policy decisions in the United

[2] In the context of this study, nodes refer to specific locations within the supply chain network where different activities and processes are taking place.

States of America (Kilian, 2008). The demand for oil significantly exceeded supply, which increased oil prices. More recently, on the other hand, Covid-19 resulted in a drop in oil prices worldwide since demand moved near to minimum use, especially in industries dependent on fossil fuels (Biswa, 2020). Any shock to oil prices will also impact GDP negatively or positively; however, that could be minimized by holding a strategic petroleum reserve (Bai & Dahl, 2018).

The strategic petroleum reserve, which can be defined as an emergency fuel store designed for use by a country in case of an external calamity or a sudden increase in price (Ogden, 2019). As such, it plays a major role in economic and social stability. The effectiveness of releasing the strategic reserve as a relief measure during emergencies has been confirmed in the literature (Anser et al., 2020; Liao, Wang, Wu, & Pan, 2016). For example, India is the fourth-largest consumer of crude oil in the world, and during the shortage of crude oil, not only was the national economy impacted negatively, but production levels also declined, and consumption fell. To stabilize the market, the strategic reserve was deployed (Biswa, 2020).

The demand on oil is increasing day by day while the supply decreases. There is a debate about a time when the world will reach its peak oil level[3] (Anser et al., 2020). Many industrial countries have started holding strategic petroleum reserves to ensure a continuous oil supply. That reflects their market, economic and security stability (Anser et al., 2020). The most recent study by Anser et al. (2020) examined the option of holding strategic petroleum reserves in South Asia as operational steps to reduce the shock of reaching the peak oil level. The study reveals that holding a strategic petroleum reserve is the best strategy to help overcome peak oil problem periods. However, there is a cost of holding strategic petroleum reserves. During the year of 1976

[3] It refers to the limited availability of oil as the world reaches its maximum oil production (Bentley, 2016).

to 2014 the cost of holding petroleum reserves in the United States was $219 billion, while the actual benefits were $122 billion (Bai & Dahl, 2018). In addition to the storage cost, there are other costs related to port logistics, land, and management (Larson et al., 2014). However, the "return" is government stability.

Usually, the national stockpile is located in a strategic location that helps a government to respond rapidly to unexpected hazards that could affect national stability. As such, it is categorized as an emergency facility (H. Li et al., 2017). The United States Department of Defense has defined strategic storage as the quantity of material that is placed in a particular geographic location due to strategic considerations or in anticipation of major interruptions in the supply distribution system. It is over and above the stockage objective (BMDO, 1997, p. 271). For example, in the Strategic National Stockpile program in the US, most of the population is within 1 hour of the CHEMPACK locations, which are found at selected hospitals or fire stations (US Public Health Emergency, 2018). The main objective of this program is to maintain a stockpile of pharmaceutical agents, vaccines, medical supplies, and equipment to augment state and local resources during a large-scale disaster or bioterrorism event. Upon request, the program will deliver materials anywhere in the United States (Esbitt, 2003). Strategic reserves can be designed to deliver critical item supplies and materials to the site of a national emergency. In order to select the appropriate strategic reserve location, a number of criteria that must be considered while evaluating the location, including transportation, safety, proximity to the distribution locations, and fairness (H. Li et al., 2017). In India, three strategic locations were selected to store the national petroleum strategic reserve with a capacity of 5.33 million tonnes (Biswa, 2020). Moreover, there is a strategic reserve at 66,000 pump stations, 300 depots, and 250 aviation terminals that could provide the nation with 77 days of oil supply (Biswa, 2020).

2.3.2 Criticality Studies

There is a group of natural raw materials that are particularly critical because of their important role in the national strategy and economy; at the same time, they are extremely exposed to a high level of supply risk (Ferro & Bonollo, 2019; Galos et al., 2021). They are an integral part of the strength of the national industries because they are components in a broad range of commodities that are used on a daily basis and required for modern technologies. Examples are cobalt, phosphate, lithium, etc. (Bobba et al., 2020). The critical raw materials has been defined as the most difficult raw materials to secure its supply (Sivek et al., 2019). Holdren et al. (2016) defined it as the vulnerability of supply chain disruption for a material that serves an essential function in producing a product in which the absence would result in a substantial consequence in the economy and national security. According to the European Commission, for a material to be considered as critical, it must face high risk with regard to access to it and represent an importance element to the national economy (European Commission, 2010). Based on the criticality definitions in the context of raw materials and products, it clearly appears that the concept stands on two main principles, as summarized by Roelich et al. (2014, p. 380):

- Supply disruption potential (P) quantifies the likelihood that access to a particular material could be restricted; and
- Exposure to disruption (E) quantifies the effect of disruption on the goal in question.

The shortage of some natural raw materials has been a concern since the 1920s. The government of the United States of America listed the rarest elements on earth that could affect the defense of the US military at that time (The U.S. National Academy of Sciences, 2008). Thirty years later, in the 1950s, the first government action – holding a strategic reserve for these elements

– was enforced to ensure defense stability. Sixty years later, the US National Research Council introduced the first matrix, known as the criticality matrix, to identify the critical raw materials from a group of minerals (The U.S. National Academy of Sciences, 2008). Following that, a number of well-cited assessment tools were developed, such as the Oko-Institute and Japanese method NEDO, the European Union assessment, the Yale Criticality Assessment, General Electric, the M5 Model, and the SCARCE method (Erdmann & Graedel, 2011; Glöser et al., 2015; Jin et al., 2016; Schrijvers et al., 2020).

Three common factors were considered to measure the criticality of raw materials: the supply risk factor; the environmental impact factor; the vulnerability to supply, national strategy, and the economy (Helbig et al., 2016). With reference to the research question, "What are the most significant variables that determine the level of importance of the critical intermediate and final products in Saudi Arabia?" Table 2 summarizes the measurement variables[4] that are most commonly being used to measure the criticality of natural raw materials on a national basis. Most of these variables were outlined by Achzet & Helbig (2013); and Helbig et al. (2016) in their articles " An Overview on How to evaluate raw materials supply risk and How to evaluate raw material vulnerability." Additional variables were added to the table considering the latest published articles related to critical raw materials.

The use of these variables is varied (Achzet & Helbig, 2013; Helbig et al., 2016; Schrijvers et al., 2020). Some previous studies, for instance, used selected variables (one to four variables) to measure the vulnerability factor and the supply risk factor, while other criticality studies used different variables to measure the same factors. In addition, some of these variables were used in studies as independent variables, while in other studies, they were used as dependent variables to measure a similar factor (Schrijvers et al., 2020). The third factor being considered is the

[4] More details discussing the measurement variables are available in Chapter four.

environmental factor: how the extraction process affects the environment and the pollution caused by the use of these raw materials.

The types of data and methodology used to measure critical raw materials are also varied. Most previous studies relied on secondary data, such as accessible government data or available index data (Galos et al., 2021; Helbig et al., 2016; Schrijvers et al., 2020). Where these are unavailable, expert judgment is considered, and it is used in some studies to quantify the variables on a four- or five-point scale (Achzet & Helbig, 2013; Galos et al., 2021; Helbig et al., 2016; Nassar et al., 2015). Different arithmetic formulas have been applied to analyze these data and determine the criticality of the raw materials on a national basis, for example, the SCARCE model (Arendt et al., 2020) or NEDO in Japan (Hatayama & Tahara, 2015).

Table 2: Critical Raw Materials Variables

#	Measurement variables	Reference
	Dimension 1: Vulnerability to Supply Restriction and Strategy	
1	National Economic	(Arendt et al., 2020; Glöser et al., 2015; Graedel, Harper, Nassar, Nuss, & Reck, 2015; Nassar et al., 2015)
2	Value of products affected	(Galos et al., 2021; Helbig et al., 2016)
3	Human Development	(Arendt et al., 2020; Glöser et al., 2015; Graedel et al., 2012, 2015)
4	Future demand	(Achzet & Helbig, 2013; Galos et al., 2021; Hatayama & Tahara, 2015; Helbig et al., 2016; Schneider, Berger, & Finkbeiner, 2013)
5	Performance substitute	(Nassar et al., 2015; Peck, Kandachar, & Tempelman, 2015)
6	Strategic importance (Importance of materials)	(Glöser et al., 2015)
7	Spread of utilization	(Arendt et al., 2020)
8	Target group demand share	(Helbig et al., 2016)
9	Consumption volume	(Helbig et al., 2016)
10	Utilization in future technology	(Gulley, Nassar, & Xun, 2018)
11	By-product dependency	(Achzet & Helbig, 2013; Galos et al., 2021; Graedel et al., 2015)
12	Risk of strategic use	(Achzet & Helbig, 2013)
	Dimension 2: Supply risk	
13	Change in imports	(Helbig et al., 2016)

Table 2 (continued)

14	Import dependence	(Arendt et al., 2020; Galos et al., 2021; Graedel et al., 2015; Helbig et al., 2016)
15	Mine production change	(Hatayama & Tahara, 2015; Helbig et al., 2016)
16	Ability to innovate	(Arendt et al., 2020; Graedel et al., 2015; Helbig et al., 2016)
17	Exploration degree	(Achzet & Helbig, 2013)
18	Company concentration	(Helbig et al., 2016)
19	Production costs in extraction	(Achzet & Helbig, 2013)
20	Available substitute	(Achzet & Helbig, 2013; Arendt et al., 2020; Galos et al., 2021; Graedel et al., 2015; Hatayama & Tahara, 2015; Nassar et al., 2015; Schneider et al., 2013)
21	Water scarcity (natural resource)	(Arendt et al., 2020)
22	Concentration of reserve	(Achzet & Helbig, 2013; Hatayama & Tahara, 2015; Schneider et al., 2013)
23	Market balance	(Achzet & Helbig, 2013)
24	Country risk (Political and economic risk)	(Achzet & Helbig, 2013; Galos et al., 2021; Glöser et al., 2015; Graedel & Erdmann, 2012; Nassar et al., 2015; Schneider et al., 2013; Telleen, 2013)
25	Mine/refinery capacity	(Achzet & Helbig, 2013)
26	Depletion time	(Achzet & Helbig, 2013; Arendt et al., 2020; Graedel & Erdmann, 2012; Graedel et al., 2015; Hatayama & Tahara, 2015; Nassar et al., 2015)
27	Future market capacity	(Achzet & Helbig, 2013)
28	Supply concentration in mining	(Arendt et al., 2020; Galos et al., 2021; Graedel & Erdmann, 2012; Graedel et al., 2015; Nassar et al., 2015)
29	Investment in mining	(Achzet & Helbig, 2013)
30	Recycling/recycling potential	(Achzet & Helbig, 2013; Galos et al., 2021; Hatayama & Tahara, 2015; Helbig et al., 2016; Schneider et al., 2013)
31	Climate change vulnerability	(Achzet & Helbig, 2013)
32	Price sensitivity	(Galos et al., 2021; Hatayama & Tahara, 2015; Helbig et al., 2016)
33	Temporary scarcity	(Achzet & Helbig, 2013)
34	Export Restrictions	(Blengini et al., 2017; Galos et al., 2021)
35	Abundance in Earth's crust	(Achzet & Helbig, 2013)
36	Policy intervention	(Glöser et al., 2015; Graedel & Erdmann, 2012; Graedel et al., 2015; Nassar et al., 2015)
37	Trade agreement	(Arendt et al., 2020; Gulley et al., 2018; Schneider et al., 2013)
38	Global production (Global concentration)	(Arendt et al., 2020; Gulley et al., 2018; Telleen, 2013)
Dimension 3: Environment		

Table 2 (continued)

39	Extraction damage	(Arendt et al., 2020; Graedel et al., 2015; Nassar et al., 2015)
40	Usage damage	(Arendt et al., 2020; Galos et al., 2021; Glöser et al., 2015; Graedel et al., 2015; Nassar et al., 2015; Schneider et al., 2013)

In this study, the types of products being tested are different from natural raw materials. Some of these variables might be applicable to measure the criticality level of intermediate and final products, but others are not. Therefore, there was a need to conduct qualitative research to explore, validate and determine the applicable measurement variables, which are presented in the result section. Indeed, one of the measurement variables being tested to measure the supply risk factor of critical intermediate and final products is the availability of the required raw materials to produce the product being tested.

Dissipation has not been considered in the criticality studies for raw materials. This might be due to the difficulties of quantifying this variable (Schrijvers et al., 2020), or it might be due to the type of products being tested. However, the qualitative result of this research shows that it is vital to measure consumer behavior concerning critical intermediate and final products and how they are purchased, used, and disposed of by the final users (Kumra, 2006). The availability of qualified personnel is an important variable when measuring the supply risk factor, particularly for critical intermediate and final products. One of the participant's experts of this study mentioned the consequences of not having people who can produce insulin in Saudi Arabia and how that might affect national security and threaten supply flow. However, 60 per cent of the health sector has undergone Saudization, including engineering and technical professions related to medical appliances, sales, and medical appliances and supplies (MHRSD, 2022). The availability of qualified personnel variable was intensively used on an organizational level to measure the

performance of external suppliers. However, it was not considered internally on a national basis as a supply risk variable to measure the criticality of the product.

On the other hand, not all of the dependent variables that measure the PEST factors were considered, such as the criticality of the product to survive, societal attitude, and return on investment, which is different from the availability of investors that being used to measure the independent supply risk factor. The use of price, government stability, and expenses as dependent variables is different from using them as independent variables to measure the supply risk factor. To measure the critical intermediate and final products on a national basis, these variables need to be considered as dependent factor measurements.

2.4 Public Procurement

Public procurement has a long history. As cited by Thai (2001), the earliest procurement order dates from between 2400 and 2800 B.C. It was found written on a red clay tablet found in Syria. The order was for 50 fragrant jars for 600 small-grain weights of smooth oil (Coe, 1989). The origin of purchasing and supply management has come a long way from its origins as being embedded in the five rights, namely quality, quantity, delivery, price, and service, as well as the operational purchasing process (Ellram et al., 2020). Purchasing and supply management shapes strategic decisions relating to globalisation, outsourcing, and sustainability. The focus used to be on private sector purchasing and supply in manufacturing, but over time it has widened to embrace the study of the public, private, and not-for-profit sectors and the manufacturing and service environments (Ellram et al., 2020).

Public procurement has an important function as a government tool; it is used to ensure sustainability and economic growth (Adjei-Bamfo, Maloreh-Nyamekye, & Ahenkan, 2019). On a

national basis, public procurement plays an important role in managing the demand of goods and services and making society better by maintaining a robust and sustainable economy and society (Benchekroun, Benmamoun, & Hachimi, 2022; Choi, 2010; Thai, 2001). It performs all activities that enable obtaining the required product from the suppliers to its final destination (Farmer & Weele, 1995; Nicoletti, 2013). It includes the purchasing function, stores, transportation and traffic, incoming inspections, quality control and assurance, and salvage and environmental issues (Farmer & Weele, 1995, p. 18). During the twentieth century, purchasing gained importance due to raw materials' scarcity (J. Gelderman, 2003, p. 16). A practical example close to the purpose of this research was in Korea. In 2009, Korea became one of the fifth largest nations to use aluminium as a raw material. At that time, the Korean public procurement service noticed the potential risk that might occur in securing the supply of aluminium due to the country's high dependency on external suppliers. As an early action to stabilise the Korean market and maintain the balance between supply and demand, the public procurement service in Korea implemented the government strategic reserve for aluminium (Choi, 2010).

I Strategic Sourcing

Strategic sourcing considers the main principle of purchasing practice. In the environment of supply risk, it considers a key success of an organization (Sislian & Satir, 2000). It can be viewed as the pattern of decisions relating to acquiring required goods and services that are consistent with the required needs (Watts, Kim, & Hahn, 1995). It's a process of identifying, evaluating, and determining the appropriate and reliable long-term sources to satisfy the requirement needs of the market (M. Saunders, 1994). It encompasses the process of finding sources of supply, guaranteeing continuity in supply, ensuring alternative sources of supply, gathering knowledge of procurable resources (Farmer & Weele, 1995, p. 19). It goes beyond the

need identification as it deals with managing the supply by developing a long-term strategic partnership, involving in supplier development by effectively enhancing supplier performance and providing continuous feedback to suppliers (Talluri & Narasimhan, 2004). It is a key function of procurement to minimize risk by ensuring the uninterrupted flow of the appropriate quality materials, products, and services (Tate, 2013).

II Purchasing Plans

"Good purchasing practices have always required good planning" (McCue & Johnson, 2010, p. 149). One of the core tasks in purchasing is planning, organizing, and directing resources needed to manage the flow of supplies for immediate requirements and to prepare and implement strategies to govern future supplies (M. Saunders, 1994). There are two main types of plans in purchasing, known as a strategic plan and a tactical plan. Strategy is the overall plan for employing resources to form a favorable position, and a tactic is a scheme to implement a specific action (M. Saunders, 1994). In other words, the strategic plan outlines the overarching goals that guide decision-makers, while the tactic specifies the steps needed to execute the strategy. In order to accomplish these plans, there are transitional plans that convert the strategic plan into a tactical plan to pursue organizational goals and objectives. Hinson & McCue (2004) classify these plans as standing and single-use plans.

Standing plans are used to guide actions that occur over time, including three types of policies, procedures, and rules and regulations. The policy provides general guidance to the action. Procedures describe the exact steps of actions to be taken in each situation. Rules and regulations explain how exactly a particular situation must be managed, Higgins and Browne (1992) as cited in (Hinson & McCue, 2004; McCue & Johnson, 2010a). Single-use plans are developed in

response to particular events to address a specific objective and then discarded (Hinson & McCue, 2004). Depending on the matter being managed, it may take years to accomplish the goal, or it may take one day. There are three single-use plans: strategic, intermediate, and operational. Strategic plans are major plans that deal with complex and more uncertain matters. It concerns obtaining or leveraging required resources to produce meaningful outcomes (Hinson & McCue, 2004), where this research is belonging to. Intermediate plans are convertible plans that translate strategy into operation. Operational plans that deal with day-to-day actions, Higgins and Browne (1992) as cited in (Hinson & McCue, 2004; McCue & Johnson, 2010a).

Usually, a decision-maker performs a process called categorisation or grouping when developing a supply strategy using the concept behind the portfolio model. This was diffused throughout strategic management after 1952, when Markowitz introduced the modern theory (C. Gelderman, 2022; Montgomery, Ogden, & Boehmke, 2018). This categorisation aims to group similar products into one particular category (Rachman, 2019). A portfolio model offers a structure that organisations can use to recognise and focus on a purchasing strategy to improve the position of items, especially those that have a very complex impact on both dimensions (Gangurde & Chavan, 2016). J. Gelderman (2003) defines the portfolio model as a framework consisting of two or more dimensions that could be used to define heterogeneous categories for which different strategic recommendations are provided. Three main concepts can be extracted from this definition, and these shaped the structure of this study: dimensions, categories, and strategic recommendations (C. Gelderman, 2022).

III Purchasing Categorization Techniques

In order to evaluate the importance level of the products, suppliers, or raw materials to the organization, two main analytical techniques are being described widely in the area of strategic sourcing. These techniques are the traditional method which is called the ABC analysis model, and KPP (C. Gelderman, 2022). Based on these models, the decision-makers are able to classify and determine the importance level of the object being analyzed. The ABC analysis provides three types of categories: A, B, and C. However, Krajic's model consists of four categories, namely strategic quadrant, bottleneck quadrant, leverage quadrant, and non-critical quadrant.

(1) ABC Analysis Model

ABC analysis is an inventory control technique that classifies inventory into three categorizations – A, B, and C – by comparing two different dimensions. 'A' items are the most important category, as the value of these items is very high, whereas the required number of items is low. 'B' items are a moderately important category, and both dimensions are equal. 'C' items are less important as the number of required items is higher than the value of the items (Torabi, Hatefi, & Saleck Pay, 2012). This technique is based on Pareto's Principle, which states that a few significant groups affect the remaining groups (Y. Chen, Li, Marc Kilgour, & Hipel, 2008; Torabi et al., 2012). Therefore, items in category A are the most important since they have a significant impact on the overall inventory cost.

Table 3: ABC Categorization

Factors	A	B	C	Total
Value of the items	60%	20%	20%	100%
Required number of items	20%	20%	60%	100%

I Limitations of the Model

Although ABC analysis has been used widely to manage inventory, there are some weaknesses in the implementation of this model. ABC analysis is based on only a single measurement, such as annual dollar usage. However, other criteria are also important in inventory classification, such as the criticality of the item and the lead time; this has been covered by other scholars: (J. X. Chen, 2012; Y. Chen et al., 2008; Ng, 2007).

One of the major weaknesses that affected the purpose of this research was recognized by (Zhenfen, Danxi, & Liuming, 2007). In their comparison study between ABC analysis and KPP, the authors reported that with the traditional ABC method, some of the classified products were classified as category A, whereas in Kraljic's matrix, they came under a bottleneck quadrant. This shows the difficulty within the ABC model of differentiating between the important and less important items. Indeed, this is one of the reasons for employing the purchasing portfolio model instead of the ABC analysis model. It is very important for this study to distinguish between the bottleneck and strategic quadrant, as the aim of the classification is to identify the exact category that the product belongs to at the national level. The lack of clear guidance makes the distinction between the priority of groups or items unclear, which does not match reality in many cases (Saueressig et al., 2017).

(2) Purchasing Portfolio Model

Purchasing Portfolio is a well-known tool in the supply chain management literature and, more specifically, in the field of purchasing. The purchasing portfolio has been extensively utilized since it was published in 1983 by Peter Kraljic in his article "Purchasing Must Become Supply Management." The tool was the first to bring portfolio models into the purchasing area

(Backstrand, Tiedemann, Bäckstrand, & Hedén, 2015; Dubois & Pedersen, 2002; Gangurde & Chavan, 2016; C. J. Gelderman & Weele, 2002; C. Gelderman & Weele, 2005). The model's main concern is about classifying the importance level of the object that is being tested. Following this approach, the organisation organises all of its possessions based on their profitability and the level of risk associated with their supply. It later assesses the supply market for these items by analysing the suppliers' bargaining power in relation to their own buying power. Afterwards, it confirms its strategic position regarding supply and plans accordingly (C. Gelderman, 2022; Kraljic, 1983).

Using a portfolio model can enhance the distribution of limited resources by categorising products, suppliers, or relationships (Turnbull, 1990). Based on two dimensions: profit impact and supply risk impact (low and high) as shown in Figure 8, the model constructed a portfolio matrix that classifies purchased products. The result is a matrix of 2 x 2 formulated into four categories: bottleneck, noncritical, leverage, and strategic. Accordingly, a strategic partnership is recommended to manage strategic products, competitive bidding for leverage products, systems contracting for noncritical products, and securing the supply for bottleneck products (C. Gelderman & Mac Donald, 2008; Kraljic, 1983).

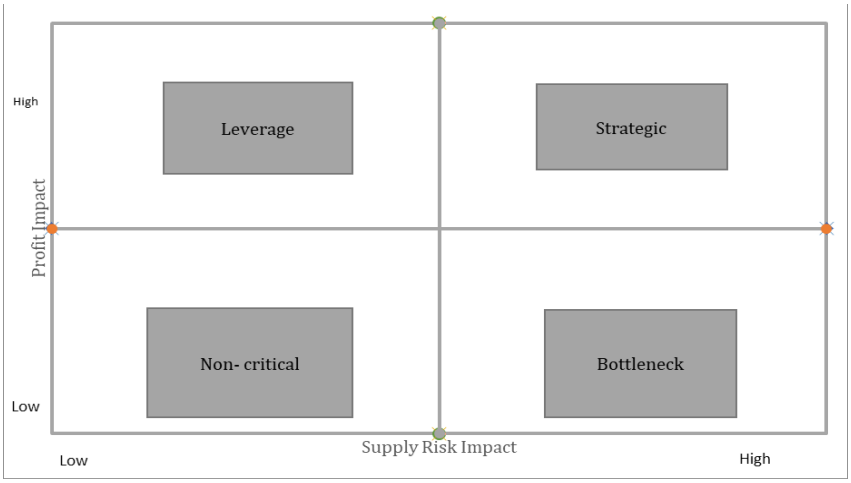

Figure 8: The Kraljic Portfolio Matrix (Kraljic, 1983)

A strategic quadrant refers to a quadrant that displays considerate influence in terms of both the profit impact and supply risk impact. Items classified within this quadrant are typically restricted when it comes to sourcing options. They are often acquired from global suppliers and hold significant value for the organization. Consequently, they require long-term supplier relationships, a precise demand forecasting, and careful make-or-buy decision (Hesping & Schiele, 2016; Isik & Vayvay, 2018; Kraljic, 1983; L. Sun et al., 2019; Weele, 2010; Zhenfen et al., 2007).

A bottleneck quadrant represents a relatively limited value in terms of money but is vulnerable with regard to supply. Since the products in this category are obtained from a very limited number of suppliers, a range of tactics must be considered, such as securing and ensuring the inventory, controlling the vendor, and preparing for a backup plan (Hesping & Schiele, 2016; Kraljic, 1983; L. Sun et al., 2019; Weele, 2010).

The most favourable quadrants are leverage and non-critical. By moving products into these quadrants, risk will be minimized, and the continuity of supply will be ensured (Rachman, 2019). Products at the leverage quadrant can be obtained from different suppliers at standard quality grades. They represent a relatively large share of the end product's cost price; therefore, they are usually purchased in large volumes (Kraljic, 1983; Zhenfen et al., 2007). Any changes to this quadrant will be reflected in the cost price of the end product. Therefore, the buyer has an opportunity, in this case, to select the best supplier, negotiate the price, and combine contract and spot purchasing (Hesping & Schiele, 2016; Kraljic, 1983; L. Sun et al., 2019; Weele, 2010). The non-critical quadrant usually has a limited value per product/item, and there are many alternative suppliers, often locally (Kraljic, 1983); therefore, it is recommended to optimize the order volume and reduce the transactional cost (Hesping & Schiele, 2016; L. Sun et al., 2019; Zhenfen et al., 2007).

Three basic risk categories are associated with a different strategic thrust. For items where the buyer has the position to dominate the market while suppliers' influence is considered moderate or weak, it is recommended it to pursue an "exploit" strategy as the risk associated with the supply is low, and the buyer has the chance to generate positive profits by leveraging favourable pricing and contractual agreements (Kraljic, 1983). This is unlike a diversifying strategy where the risk in supply is high (Kraljic, 1983). In this case, the buyer must defend themselves and start looking for other materials substitutes and new suppliers. Between the exploiting and diversifying strategies, a balanced strategy is one where the power between both parties is equal (Kraljic, 1983). The final phase of the model suggests strategies and action plans based on the classification category in the previous phase (Kraljic, 1983), as shown in Figure 9.

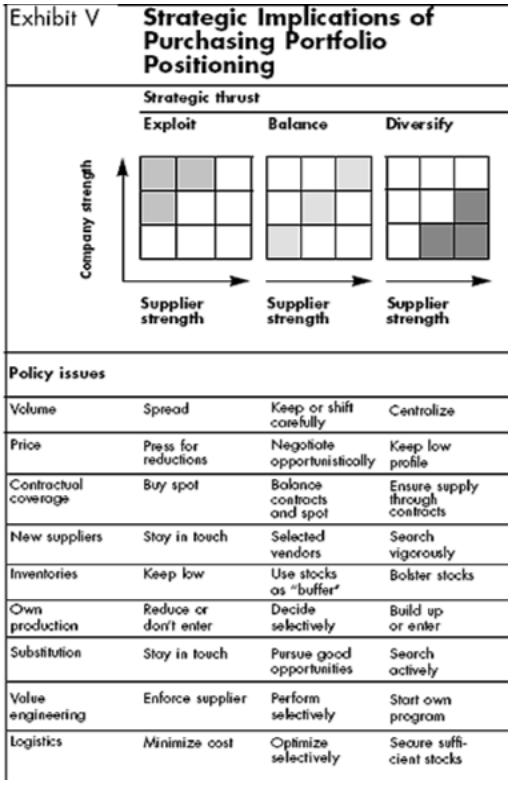

Exhibit V **Strategic Implications of Purchasing Portfolio Positioning**

	Strategic thrust		
	Exploit	Balance	Diversify
Company strength			
	Supplier strength	Supplier strength	Supplier strength
Policy issues			
Volume	Spread	Keep or shift carefully	Centralize
Price	Press for reductions	Negotiate opportunistically	Keep low profile
Contractual coverage	Buy spot	Balance contracts and spot	Ensure supply through contracts
New suppliers	Stay in touch	Selected vendors	Search vigorously
Inventories	Keep low	Use stocks as "buffer"	Bolster stocks
Own production	Reduce or don't enter	Decide selectively	Build up or enter
Substitution	Stay in touch	Pursue good opportunities	Search actively
Value engineering	Enforce supplier	Perform selectively	Start own program
Logistics	Minimize cost	Optimize selectively	Secure sufficient stocks

Figure 9: Strategic Implication of Purchasing Portfolio Positioning (Kraljic, 1983, p.115)

Mapping products in the Kraljic Purchasing Portfolio (KPP) depends on the qualitative assessment obtained by asking experts to evaluate the products subjectively using a scale of low

to high for both dimensions, profit impact and supply risk impact (Padhi et al., 2012). In respect to the variables that are used by Kraljic to measure both dimensions, the following Table 4 summarizes these variables (C. Gelderman, 2022; C. Gelderman & Mac Donald, 2008; Kraljic, 1983; L. Sun et al., 2019):

Table 4: Kraljic's Purchasing Portfolio Variables

Profit Impact	Supply Risk
Volume purchased	Market conditions
Expected growth in demand	Availability/scarcity
Percentage of total purchase cost	Number of suppliers
Impact on product quality	Competitive demand
Business growth	Make-or-buy opportunities
	Storage risks
	Substitution possibilities

I Limitations of the Model

Kraljic introduced the first portfolio model for developing purchasing function (Backstrand et al., 2015; Dubois & Pedersen, 2002; Gangurde & Chavan, 2016; C. J. Gelderman & Weele, 2002; C. Gelderman & Weele, 2005). Although it is not presented as a theory, it has the key components of a theory (Pagell, Wu, & Wasserman, 2010). That has been confirmed recently by C. Gelderman (2022). It provides a comprehensive action plan, unlike the traditional purchasing tool ABC analysis (C. Gelderman & Weele, 2005). Therefore, it is considered to be the most important tool in strategic sourcing (C. Gelderman, 2022; Zhenfen et al., 2007).

As the literature review shows, the model has been used widely in the purchasing field (C. Gelderman, 2022; Montgomery et al., 2018). It also gives a better understanding of the strategic issues at hand (C. J. Gelderman & Weele, 2002). By understanding the sources of risk through their assessment, purchasing managers can take a proactive, long-term view in order to reduce and

manage that risk (Zsidisin, Ellram, Carter, & Cavinato, 2004). Although it is a simple model, it offers a valuable structure for gathering market and corporate information, forecasting future supply situations, and determining suitable procurement approaches to acquire essential products and materials. The quadrant methodologies offer valuable insights to decision-makers who aims to mitigate supply risks and optimize their position as buyers (Backstrand et al., 2015). It considers a mapping tool that helps to identify the critical path to obtaining the required products through that the supplier has the capability to satisfy the required needs, based on market demand changes (Terpend, Krause, & Dooley, 2011). By determining and identifying the position of critical products, it could be used as an indicator tool to determine which type of product a nation needs in order to minimize and mitigate the potential risk that might occur.

The model employs only low and high levels for arranging products in the KPP. This leads to a 2x2 matrix, which is discreet and convenient, but in the process, it loses the finer distinctions between the products in each cluster (Padhi et al., 2012). It is questionable whether the variables that measure the level of dimensions are appropriate as a measurement (Nellore & Soderquist, 2000). Using a subjective method where the purchasing manager positions the products makes the model imprecise. Furthermore, it does not provide guidelines for the strategic movement of products and/or suppliers within the matrix (C. J. Gelderman & Weele, 2002). However, to the best of the researcher's knowledge, all these issues have been resolved by former researchers, as the following section illustrates.

2.5 Studies on Purchasing Portfolios

This section includes studies that have applied the purchasing portfolio model at different levels and with varying scopes. These are organised, discussed, and critiqued based on the extracted themes proposed by J. Gelderman (2003) for this particular type of study: dimensions,

categories, and strategic recommendations. This section also considers the unit of analysis, which in this study is intermediate and final products at a national level. With regard to the aim of this study, the focus is confined to models that are used in the area of purchasing in terms of identifying and managing required resources.

I Dimensions

Many researchers who have used a purchasing portfolio matrix modified their factors to fulfil the purpose of their studies. For instance, some studies aim to classify products based on the strategic value they represent to the company, or on the level of supplier commitment to the green supply chain. In 1997, Ellram and Olsen proposed a model using the principle of two portfolios: the KPP (Kraljic, 1983) and Accounting Portfolio Analysis (APA) (Fioccat, 1982). Building a loyal relationship with suppliers was the emphasis of the study, as exploiting strategy considers a dangerous relationship with a loyal supplier. To mitigate this risk, the authors proposed a three-step analysis procedure. The first step is based on the Kraljic portfolio using two dimensions – the strategic importance compared with the difficulty of managing the purchase. Each of these consists of a number of measurement variables, as shown in Tables 5 and 6. The results of these dimensions are four quadrants similar to those in the Kraljic portfolio: non-critical, leverage, bottleneck, and strategic.

Table 5: Factors Describing the Strategic Importance Dimension (Ellram & Olsen, 1997, p. 104)

Competence factors	Economic factors	Image factors
The extent to which the purchase is part of the firm's core competencies. Purchasing improves the knowledge of the buying organisation and their technological strength	Volume or dollar value of purchases, the extent to which the purchase is part of a final product with great value-added, the extent to which the purchase is part of a final product with good profitability, and the criticality of the purchase in terms of gaining leverage with the supplier for future purchases	Supplier critical image/ brand name, potential environmental/safety concerns

On the other hand, the difficulties of managing the purchase situation are described in the following variables:

Table 6: Factors Describing the Difficulty of Managing the Purchase Situation Dimension (Ellram & Olsen, 1997, p.104)

Product characteristics	Supply market characteristics	Environmental characteristics
Novelty, complexity	Suppliers' power, and technical and commercial competence	Risk, uncertainty

The second step is where the second portfolio technique (the APA) is applied. This is a strategic marketing tool used to analyse an organisation's products, services, or customers with the aim of developing an effective marketing strategy (Fioccat, 1982). The model consists of two dimensions different from those utilised in step one: supplier attractiveness and the strength of the relationship. Each of these factors contains different measurement variables, which are presented in Tables 7 and 8. According to the APA, the portfolio consists of nine quadrants numbered from one to nine, as shown in Figure 10. A circle is used to represent the actual buyer-supplier relationship. The size of the circle relates to the relationship: the bigger the circle, the more resources are allocated to that relationship. At the same time, the position of the circle indicates which category the supplier is classified in. To categorise the purchases in a portfolio model, the authors suggested assigning a weight to each dimension and carrying out a subjective evaluation by asking the decision-makers their opinions about the object being tested.

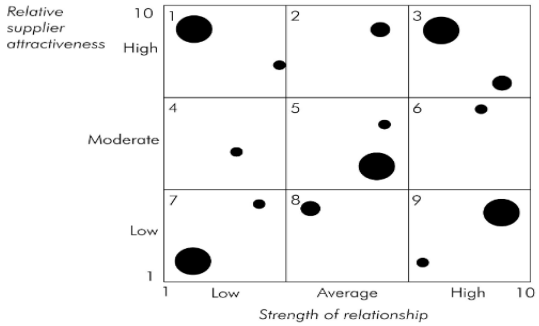

Figure 10: Analysis of supplier relationships adopted from (Ellram & Olsen, 1997, p. 107)

In the third and final step of the model, the authors proposed an action plan for each group. The nine quadrants were divided into three different groups: cells 1, 2, and 4; cells 3, 5, and 6; and cells 7, 8, and 9.

Table 7: Factors Describing the Strategic Importance Dimension (Ellram & Olsen, 1997, p. 106)

Financial and economic factors	**Performance factors**	**Technological factors**	**Organisational, cultural, and strategic factors**	**Other factors**
The supplier's margins, the supplier's financial stability, the supplier's scale and experience, barriers to the supplier's entry and exit, slack	Delivery, quality, price	The ability to cope with changes in technology, the types and depth of the supplier's current and future technological capabilities, the supplier's current and future capacity utilisation, the supplier's design capabilities, the supplier's speed in development, and the supplier's patent protection	Influence on the company's network position, the internal and external integration of the supplier, the strategic fit between buyer and supplier, management attitude/outlook for the future, top management capability, compatibility across levels and functions of buyer and supplier firms, general risk and uncertainty of dealing with the supplier, feeling of trust in relation to the supplier	Ability to cope with changes in the environment, safety record of the supplier

On the other hand, the Strength of the Relationship variables are described in Table 8:

Table 8: Factors Describing the Strength of the Relationship Dimension (Ellram & Olsen, 1997, p. 107)

Economic factors	Character of the exchange relationship	Cooperation between buyer and supplier	Distance between the buyer and the supplier
Volume or dollar value of purchases, the importance of the buyer to the supplier, exit costs	Types of exchange, level and number of personal contacts, number of other partners, duration of the exchange relationship	Cooperation in development, technical cooperation, integration of management	Social distance, cultural distance, technological distance, time distance, geographic distance

The lack of empirical study is considered one of the weaknesses of this model, and in purchasing portfolio studies, it is one of the most important elements of developing a model (J. Gelderman, 2003). Step one is most likely the Kraljic portfolio with different names for the dimensions. Looking at the variables for each dimension, they reflect the supply risk and profit impact dimensions in Kraljic's model, as do the measurement variables in step two. In addition, the study left us with a question: when applying two different portfolio techniques with different dimensions and variables, how can the results be matched? If the supplier is classified in step one as a strategic supplier, will they also be classified as strategic supplier in step two? How, with a different portfolio technique and measurement variables, is that possible? In terms of section three, the action plan, the authors recommended a good strategic plan; however, the study fails to provide the source of the recommendations or to clarify why and how they arrived at these recommendations. Are they based on previous studies, expert interviews, or their own experience?

To confirm the measurement criteria of the buyer-supplier relationship, Hudnurkar, Rathod, and Jakhar (2016) carried out intensive research by interviewing Indian purchasing managers. Most of them had never used or heard of a purchasing portfolio. The study confirmed most of the variables being used by Kraljic and other studies, and it added five more criteria to the

literature: contractual agreements, the complexity of the specification, power position, supplier selection, and exclusivity of supplies, see Table 9.

Table 9: Existing and New Supplier Criteria (Hudnurkar et al., 2016)

Existing Literature		New Variables
1. Cost of item supplied, 2. Volume of business, 3. Criticality of item, 4. Relationship level, 5. Years of association, 6. Resource/risk sharing/investment, 7. Involved in product development, 8. Involved in product innovation and improvement, 9. Commitment to quality, 10. Commitment to delivery,	11. Technical competency, 12. Experience in business, 13. Price negotiation/sensitivity, 14. Past track record, 15. Responsiveness to change, 16. Regularity of supplies, 17. Mutual dependency, 18. Knowledge transfer, 19. End customer is affected, 20. Switching cost, 21. Information sharing.	1. Contractual agreements, 2. Complexity of specification, 3. Power position, 4. Supplier selection, 5. Exclusivity of supplies.

The steel industry was the setting for the study by X. Liu and Xu (2008). It requires a large quantity of raw materials, fuel and a stable supply flow (X. Liu & Xu, 2008). Two dimensions were compared to improve the manufacturing process: the impact of production on the profit and the supply risk factor. The study aimed to quantify the measurement method using a fuzzy comprehensive evaluation. Although the measurement variables were described in depth and matched the purpose of the study, the authors did not illustrate how these variables had been extracted, see Table 10. In addition, the result of the study only reveals that both dimensions were high in reference to the strategic quadrant, but it does not present the matrix or illustrate the exact position of the object being studied – "scrap." Nevertheless, the authors proposed a strategic direction for all four quadrants: non-critical, leverage, bottleneck, and strategic.

Table 10: Steel Industry Portfolio (X. Liu & Xu, 2008)

Profit impact			Supply risk
Production Attribute	**Purchasing Attribute**	**Inventory Attribute**	
- Relevance to strategy - Manufacturing processes - Impacts on quality - Impact on quantity - Quantity and frequency requirement - Level of security on humans or machinery - the environmental impact	Impact of purchasing on profit	- Price - Service and storage space cost - Risk cost	- The degree of scarcity - The agility of supply - The stability of quality - The stability of the price

A study by C. Gelderman and MacDonald (2008) examined working in a remote area where there is no market or supplier, as this is a major supply/logistics challenge. The Kraljic variables portfolio is designed to measure the flow of supply in a normal environment where there are no issues with the logistic infrastructure, such as those caused by being in a remote area (C. Gelderman & MacDonald, 2008). Similar to this research, the study used the five-step approach that was proposed by J. Gelderman (2003). After determining the measurement variables of the model where the proposed variables by Kraljic for the profit impact were used, the supply risk factors were extracted from the literature (see Table 11). A focus group was conducted with internal experts in different departments and external procurement consultants to test and analyse 44 products. The model can significantly improve a company's purchasing portfolio. However, the authors failed to mention how these variables were calculated and how they positioned them in the matrix. The only aspect they mentioned was the use of mathematical formula. With regard to the strategic recommendation, the authors made use of the existing strategic plan provided by Kraljic in his article.

Table 11: Staatsoile Suriname (C. Gelderman & mac Donald, 2008)

Supply risk	
1. Market conditions	9. Cultural differences
2. Availability/scarcity	10. Lack of logistical knowledge
3. Number of suppliers	11. Supply interruptions (strikes, hurricanes, etc.)
4. Competitive demand	12. Duty and customs regulations
5. Make-or-buy opportunities	13. Shortage of qualified personnel
6. Storage risks	14. Complicated import procedures
7. Substitution possibilities	15. Payment conditions
8. On-time delivery (lead times)	16. Logistics-related facilities (harbour, roads, warehouses, communications, etc.)

An empirical study in a complex area where construction is carried out on a temporary site was conducted by Ferreira, Arantes, and Kharlamov (2015). The purchasing portfolio model was shown to be credible for defining the purchasing strategies of the company, as well as for providing guidelines for their application. The study developed a slightly different five-step approach from that proposed by J. Gelderman (2003) in terms of identifying the criticality level of the construction items. The model starts by defining the relevant criteria; the researchers considered the existing variables in the literature, then proposed them to the company's experts. The second step was prioritising these criteria with the use of the AHP model. By identifying the measurement criteria, items were rated using a scale from 1–5, where one was considered the worst and five was the best score for the construction item class. Depending on the result obtained in step three, step four consists of applying a multidimensional scale (MDS) model to position the items in the purchasing portfolio matrix. The final step is the validation step, where the researchers met the company's expert and presented the result. Upon evaluation, the study appears to be a strong contribution to the field with a clear objective, rigorous methodology, and comprehensive results. One of the most important variables in this industry that could be questioned is the make-or-buy decision, which

was not one of the measurement variables, as shown in Table 12. However, looking at the nature of the items being tested, we can see a possible answer to this question as the buying decision is most applicable to all, if not all, of the variables.

Table 12: Selected Criteria for the Construction Industry (Ferreira et al., 2015)

Strategic impact instead of profit impact	Supply risk impact
	- Supplier available on the construction site local market
- Total amount of purchased items	- Product availability
- Expected growth in the company's demand	- Substitution possibilities
- Perceived bargaining power of the buyer	- Product storage costs
- The importance of the product in the project sequence	- Legal Requirements
	- Ease of supplier substitution in case of failure
	- Logistical proximity of supplier market
	- Number of available suppliers

Cai, Yu, and Xia (2014) added a third dimension to the purchasing portfolio model by combining it with machine learning, namely the Support Vector Machine (SVM). This was then applied in the aircraft industry. Four main steps can be identified in the model development. The authors started by reviewing the literature to determine the study dimensions that were relevant to quality, with a focus on aircraft and helicopter studies. In the second step, the authors applied the AHP method to evaluate and determine the most applicable criteria for measuring quality in the aircraft industry, as shown in Table 13.

Table 13: Measurement Variables for Aircraft Industry (Cai et al., 2014)

Quality basic value (X)	Quality influence value (Y)	Quality cost (Z)
Qualification rate, qualification failure rate, and quality stability	Mean time to repair, impact depth, and influence range	Quality management, detection complexity, and quality traceability

The third step of the study comprised adding the third dimension to the purchasing portfolio matrix. The three dimensions are: the quality basic value (X) abscissa, the quality influence value (Y) ordinate, and the quality cost (Z) vertical. Each of these dimensions has two measurement levels, low and high (2x2x2). That divides the aircraft materials into eight categories: general materials (X: high, Y: low, Z: low); key materials (X: high, Y: low, Z: high); lever-type materials (X: high, Y: low, Z: high); core materials (X: high, Y: high, Z: high); adjustable materials (X: low, Y: low, Z: low); risk materials (X: low, Y: high, Z: -); bottleneck-type materials (X: -, Y: low, Z: high), and finally strategic materials (X: -, Y: high, Z: high). These are illustrated in Figure 11 (Cai et al., 2014).

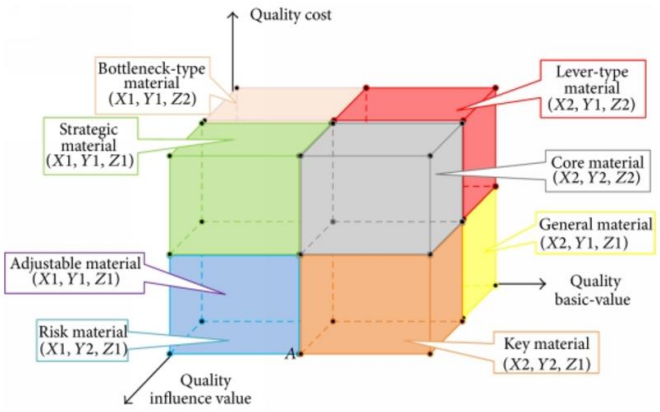

Figure 11: Three-Dimensional Model Diagram of Material Classification (Cai et al., 2014)

With regard to the fourth step, analysing the items, the authors used SVM, which is one of the machine learning methods proposed by Cortes and Vapnik (1995). This was again a new objective method for classifying items using a purchasing portfolio. However, two points are missing in this study: details of the experts involved in the study, and strategic recommendations, which the authors stated was a study limitation. Overall, this is a remarkable study using a third dimension in a purchasing portfolio combined with the SVM model.

Boiler parts were the case used by Gangurde and Chavan (2016) to test the capability of a purchasing portfolio to improve their management and mitigate their risk through a mixed-methods approach combined with a slightly modified version of the five-step approach proposed by J. Gelderman (2003). During the preparation phase, the authors clearly illustrated the objective of the study, identifying the type of data required, which were both qualitative and quantitative. In step two, the authors designed the portfolio matrix in which they used the profit impact and supply risk factors with modified criteria, as illustrated in Table 14 below. At this stage, the authors assigned a weight to each criterion using a scale of 1–5. One point missing at this stage is an illustration of the analysis techniques they used to prioritise the criteria. Obviously, this is an objective method, but there is no mention of which technique they applied; it would enhance the credibility of the model if they applied a mathematical formula or used MDS, SVM, etc. With that, they moved to step four, where they discussed the parts position with the study sample. Finally, they provided a strategic recommendation, which is one of the strongest contributions of this study.

Table 14: Boiler Dimensions

Profit impact	**Supply risk**
Quality, supplier's technology, joint growth, relationship building, cost of product, cost of relationship	Flexibility, delivery, supply constraint, supplier's profile

Many other studies have been carried out using the principle of a purchasing portfolio as the basis of their model. Most were conducted for similar purposes and scopes, which provide valuable insights into the model. This study examines the criticality level of products on a national basis, which required different dimensions and measurement variables as well as the sampling of the study who could assess the type of product on the national level. Therefore, the focus here was directed toward studies that fulfilled the three key elements of a purchasing portfolio: identifying

the measurement factors, categorisation and positioning, and providing a strategic recommendation.

II Categorization and Positioning

Most studies used the purchasing portfolio as a base model for their own. The model contains four quadrants. Each has its own features and role, represented by a name indicating the level of the quadrant's importance. The model begins with the highest level of impact in both dimensions, which is called the strategic quadrant, and it ends with the lowest impact on both dimensions, which is a non-critical quadrant (Kraljic, 1983). The bottleneck quadrant occurs when the level of impact on the supply risk factor is higher than the profit impact, and leverage occurs when the profit impact is higher than the supply risk factor (Kraljic, 1983). Table 15 lists the most cited published studies and uses found in the literature modified the model dimensions and categories:

Table 15: Summary of Strategic Sourcing Models

#	Author/s	Date	Matrix Name	Factors	Categories	Citation
1	Peter Karljic	1983	Kraljic Purchasing Portfolio	Profit impact, Complexity and Risk Profile	Strategic, Leverage, Bottleneck, Non-Critical	(Kraljic, 1983)
2	Elliott-Shircore and Steele	1985	Procurement Positioning Overview	Profit/value potential and Supply vulnerability	Strategic critical, Tactical profit, Strategic security, Tactical acquisition	(C. Gelderman & Weele, 2005; Narsimhan & Ungarala, 2016)
3	Olsen and Ellram	1997	Portfolio Model	Strategic Importance and Difficulty of Managing	Strategic, Leverage, Bottleneck, Routine	(Ellram & Olsen, 1997)
4	Bensaou	1999	Portfolio Model	Buyer-specific investment and Supplier-specific investment	Strategic partnership, Captive buyer, Captive supplier, Market exchange	(Bensaou, 1999)

Table 15 (continued)

5	Lilliecreutz and Ydreskog	1999	Classification mode	Importance of purchasing (Economic Profile) and Complexity and risk profile	Strategic, Leverage, Bottleneck, Routine	(Lilliecreutz & Ydreskog, 2001)
6	Wynstra and Pierick	2000	Supplier Involvement Portfolio	Degree of responsibility for product development and Development risk	Strategic Development, Critical Development, Arm's length development, Routine Development	(Wynstra & Pierick, 2000)
7	Cox	2001	The Attributes of Buyer and Supplier Power	Attributes of Buyer Power Relative to Supplier and Attributes of Supplier Power Relative to Buyer	Interdependence, Buyer Dominance, Supplier Dominance, Independence	(Cox, 2001)
8	Arjan J. van andWeele	2002	Purchasing Strategies	Strategic Importance and Supply Risk	Strategic, Leverage, Bottleneck, Non-Critical	(C. Gelderman & Weele, 2005)
9	Wynstra, Axelsson, and Valk	2006	Impact-based classification of business services	Impact on internal customers and Impact on downstream customers	Major semi-manufactured services, Major component services, Major instrumental services, and Major consumption services All minor services	(Wynstra, Axelsson, & Valk, 2006)
10	Caniëls, and Gelderman	2007	Kraljic matrix	Profit impact and Supply risk	Strategic, Leverage, Bottleneck, Non-Critical	(Caniëls & Gelderman, 2007)
11	Zhenfeng, Danxia, Liuming	2007	Dimensions and categories in the Kraljic matrix	Profit impact and Supply risk	Strategic, Leverage, Bottleneck, Non-Critical	(Zhenfen et al., 2007)
12	Liu and Xu	2008	Purchasing Portfolio	Production attribute and Supply risk	Strategic item, Leverage item, Bottleneck item, Non-Critical item	(X. Liu & Xu, 2008)
13	Gelderman and Mac Donald	2008	Staatsoile's Portfolio Matrix: Clusters	Profit impact and Supply risk	Strategic item, Leverage item, Bottleneck item, Non-Critical item	(C. Gelderman & mac Donald, 2008)

Table 15 (continued)

14	Pagell, Wu, and Wasserman	2010	The Sustainable Purchasing Portfolio Matrix	Threat to Triple Bottom Line and Supply Risk	Strategic, Strategic Commodity, Transitional Commodity, and True Commodity, Bottleneck, Non-critical item	(Pagell et al., 2010)
15	Lee and Drake	2010	Purchasing Portfolio	Components value and Supply risk	Strategic item, Leverage item, Bottleneck item, Non-Critical item	(D. M. Lee & Drake, 2010)
16	Padhi, Wagner, and Aggarwal	2012	Kraljic Portfolio Matrix	Profit impact and Supply risk	Strategic, Leverage, Bottleneck, Non-Critical	(Wagner, Padhi, & Bode, n.d.)
17	Ferreira, Arantes, and Kharlamov	2014	Production Planning and Control	Strategic Impact and Supply Risk	Strategic, Leverage, Bottleneck, Non-Critical	(Ferreira et al., 2015)
18	Cai, Yu, and Xia	2014	Three-dimensional model diagram of material classification	Quality eigenvalue Quality influence value Quality cost	General material, Key material, Lever-type material, Core material, Adjustable material, Risk material, Bottleneck-type material, Strategic material	(Cai et al., 2014)
19	Narsimhan and Ungarala	2016	Competitive Business Negotiation Tactic and Kraljic Category	Procurement Value and Supply/Opportunity risk	Strategic item, Leverage item, Bottleneck item, Routine item	(Narsimhan & Ungarala, 2016)
20	Grngurde and Chavan	2016	Interpretation of Kraljic's Matrix	Impact on Profit and Supply Risk	Strategic, Leverage, Bottleneck, Non-Critical	(Gangurde & Chavan, 2016)
21	Botes, Niemann, and Kotze	2017	Supplier categorization	Expected losses and Availability of alternative suppliers	Strategic, Leverage, Bottleneck, Non-Critical	(Botes et al., 2017)
22	Mello, Eckhardt, and Leiras	2017	Score of classification item	Procurement Importance and Complexity of the supplier market	Strategic, Leverage, Bottleneck, Non-Critical	(Magalhães, Eckhardta, & Leirasa, 2017)
23	Rachman and Nofrisel	2018	Mapping results of the Kraljic matrix	Profit impact and supply risk	Strategic, Leverage, Bottleneck, Non-Critical	(Rachman, 2019)

Table 15 (continued)

24	R Irfanto, Maisarah, M Abduh	2019	Kraljic Matrix Results for Building Project	Value axis and Risk axis	Strategic, Leverage, Bottleneck, Non-Critical	(Irfanto et al., 2019)
25	Bianchini, Benci, Pellegrini, and Rossi	2019	Kralic Matrix	Profit impact and Supply risk	Strategic, Leverage, Bottleneck, Non-Critical	(Bianchini, Benci, Pellegrini, & Rossi, 2019)
26	Garzon, Enjolras, Camargo, and Morel	2019	Raw material distribution in Kraljic matrix by supplier Potential	Strategic Value and Assessment Risk	Strategic, Leverage, Bottleneck, Routine	(Garzon, Enjolras, Camargo, & Morel, 2019)
27	Tip, Vos, Peters, and delke	2021	Impact of the Pandemic on Supply Risk and Profit Impact	Profit impact and Supply risk	Strategic, Leverage, Bottleneck, Routine	(Tip, Vos, Peters, & Delke, 2021)
28	Abdulsalam, Alibrahim, Alhuwail, & Behbehani	2022	Supply classification matrix for pharmaceutical subcategories related to diabetes treatment.6of9 |ABDULSALAMET AL.	Financial exposure and Supply exposure	Strategic, Leverage, Bottleneck, Noncrtical	(Abdulsalam, Alibrahim, Alhuwail, & Behbehani, 2022)

To determine the exact position of the products, items, etc., on the Purchasing Portfolio matrix, the base was built on subjective judgments (Padhi et al., 2012). Purchasing professionals were asked to evaluate a given product or item on the basis of two levels, high and low impact. That inspired the researchers to propose an objective judgement instead of using a subjective method. Two common steps were employed during the research that most of the positioning objective literature follows. These were assigned a weight to each variable using different scale methods, then positioning the product or item being evaluated in the portfolio matrix.

To identify the weight of each variable using a quantitative method, several methods and techniques can be employed. The most cited technique is the triangular fuzzy number (TFN), as

shown in Table 16. It was applied to convert experts' opinions into accurate numbers (Chou & Chang, 2008; X. Liu & Xu, 2008; Padhi et al., 2012; L. Sun et al., 2019).

Table 16: Linguistic Scale and Corresponding TFN

Linguistic scale point	Degree of impact	TFN
1	Non / Negligible	(1, 1, 2)
2	Extremely low / Very less	(1, 2, 3)
3	Very low / Less	(2, 3, 4)
4	Low / Normal	(3, 4, 5)
5	Medium-low / Much	(5, 6, 7)
6	Medium / Too much	(5, 6, 7)
7	Medium-high / Extra	(6, 7, 8)
8	High	(7, 8, 9)
9	Very high	(8, 9, 10)
10	Extremely high	(9, 10, 10)

The scoring matrix has been used to quantify experts' opinions into quantitative data in order to objectively analyse it, as shown in the following Figure 12 (Ellram & Olsen, 1997; D. M. Lee & Drake, 2010). The Likert scale was also implemented in several studies see for example (Gangurde & Chavan, 2016; J. Gelderman, 2003; D. M. Lee & Drake, 2010; Terpend et al., 2011).

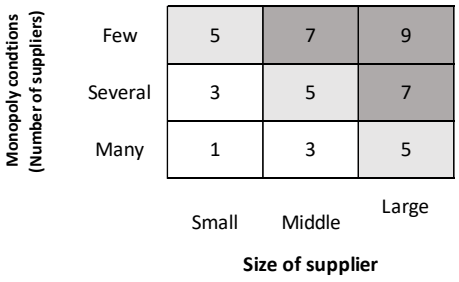

Figure 12: Supply Risk Scoring Matrix - Adopted from (D. M. Lee & Drake, 2010)

The most common quantitative technique used to identify model weights is the Analytical Hierarchy Process (AHP) (Montgomery et al., 2018). Bianchini et al. (2019); Ellram & Olsen (1997); Ferreira et al. (2015); Garzon et al. (2019); D. M. Lee & Drake (2010); Turnbull (1990) implemented the AHP, which aims to assist decision-makers in making decisions in our complex

world (Saaty, 1988). It is a three-part process that involves identifying and organizing decision objectives, criteria, constraints, and alternatives into a hierarchy. Pairwise comparisons are then made between the relevant elements at each level of the hierarchy (Saaty, 1988; Saaty & Vargas, 2001). It helps to set the priorities for making the best decisions using both qualitative and quantitative data (D. M. Lee & Drake, 2010). Nevertheless, it requires human intervention to assign performance values (Sepulveda, Derpich, & Bull, 2014).

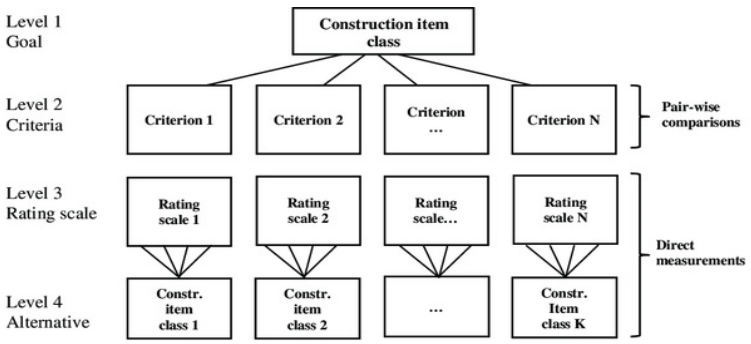

Figure 13: A simple AHP Model for the Analysis of Purchasing Portfolio Matrix Dimensions in the Construction Sector – Adapted from (Ferreira et al., 2015; D. M. Lee & Drake, 2010)

Ellram & Olsen (1997); Garzon et al. (2019); X. Liu & Xu (2008); Magalhães et al. (2017) used the Narasimhan (1983) method to assign weights to factors (see Figure 14).

	f_1	f_2	...	f_n	a
f_1	x_{11}	x_{12}	...	x_{1n}	a_1
f_2	x_{21}	x_{22}	...	x_{2n}	a_2
...	...	...	...	...	...
f_n	x_{n1}	x_{n2}	...	x_{nn}	a_n
				Sum	1.0

Where: n The number of factors.

f_i A factor.

x_{ij} The result of an evaluation of factor i's importance compared to factor j's importance using a scale from 1 (equally importance) to 9 (absolute importance). If factor i is less important than factor j, x_{ji} is evaluated instead. The matrix is completed by using the equation: $x_{ij} = 1/x_{ji}$.

a_i The weight of factor i. $a_i = Z_i / S$. Where:

$$Z_i = \sqrt[n]{x_{i1} * x_{i2} * \ldots * x_{in}}, \quad S = \sum_{j=1}^{n} Z_j .$$

Figure 14: Calculation of Methodology to Assign Weights (Narasimhan (1983) method) – Adopted from (X. Liu & Xu, 2008)

The Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE) is an implemented ranking method by (Sepulveda et al., 2014). PROMETHEE was proposed by Jean Brans in (1982), and it is based on outranking relationships between pairs of alternatives (Deshmukh, 2013; Z. Sun & Han, 2010). It induces the preferential function to describe the preference difference between pairs of alternatives for each criterion (Z. Sun & Han, 2010). Thus, preference functions about the numerical difference between pairs of alternatives are built to describe the preference difference from the point of view of the decision-maker (Z. Sun & Han, 2010). These functions' values range from 0 to 1. The bigger the function's value is the larger difference of the preference. When the value is zero, there is no preferential difference between pairs of alternatives; however, when the value is one, one of the alternatives is strictly outranking the other (Z. Sun & Han, 2010).

The principle of the Pareto distribution was applied by (Garzon et al., 2019) to select the three main items out of ten strategic items classified by the purchasing portfolio. The same analysis model was applied by (Bianchini et al., 2019). Zhenfen et al. (2007) chose 20 per cent as the division point for the portfolio matrix, meaning that bottleneck items are defined by an 80 per cent rank of profit impact and a 20 per cent rank of high risk. The Pareto model relies on what is called a power-law distribution. A power-law distribution has the property that smaller numbers are rare and larger numbers are more common (Nair, Sankaran, & Balakrishnan, 2018). The concept behind the method is clear – selecting the most critical items that influence others.

Cai et al. (2014) used machine learning SVM to position the items into the purchasing portfolio matrix, as mentioned earlier on page (61). To position the supplier into the purchasing matrix based on the level of supplier complexity, (Magalhães et al., 2017) used a scale from 1 to 9 to determine the importance of each variable. Then they used half the score (4.5) as a switching

point on the quadrant, as shown in Table 17. The method is more acceptable than subjective evaluation as it provides a weight for each variable.

Table 17: Score for Item Classification (Magalhães et al., 2017)

		< 4.5	**>= 4.5**
Procurement importance	>= 4.5	Leverage	Strategic
	< 4.5	Non-critical	Bottleneck
		Complexity of the supplier market	

Ferreira et al. (2015), Padhi et al. (2012), and Rachman (2019) applied a Multidimensional Scaling (MDS) model using SPSS software to position the items into the purchasing portfolio matrix after distributing a questionnaire among purchasing experts. The model positions the products in the matrix in a way that matches reality. They confirmed the result by inserting an additional step after implementing the model in order to confirm the result with expert sampling.

To provide a simple and flexible instrument model, Excel was selected as an analysis tool for (Bianchini et al., 2019) study. C. Boehmke, T. Montgomery, A. Ogden, & K. Freels (2017) introduced an R package using the statistical software "R." It allows a firm to strategically analyze its purchasing portfolio with single and multi-attribute value analysis to measure purchasing characteristics. Other studies used statistical software analysis without mentioning the name of the software being used, such as (Bensaou, 1999; Dabhilkar et al., 2016; C. Gelderman & Mac Donald, 2008; C. Gelderman & Weele, 2005; Hesping & Schiele, 2016; Luzzini, Caniato, Ronchi, & Spina, 2012). For the present study, the Multidimensional Scaling (MDS) model was chosen as it has been confirmed by other studies the capability of the model to position the product into the matrix, which matches the reality. First, a Likert-type scale is used in a questionnaire on the tested product, and then IBM SPSS software version 28 is used to analyze and position the major national products on the matrix.

III Strategic Recommendation

As discussed earlier in section 2.4, each quadrant of the matrix provides decision-makers with an appropriate strategic action that needs to be taken to manage the product being classified in. Caniëls and Gelderman (2005) tested the strategic action recommended by Kraljic for each quadrant. Interdependence and the balance of power were the main elements that characterized the strategic quadrant, similar to the non-critical quadrant. On the other hand, the bottleneck quadrant was mainly dominated by suppliers, while the leverage quadrant was dominated by buyers. The strategies confirmed by their study are given in Table 18.

Table 18: Tested Purchasing Strategy (Caniëls & Gelderman, 2005, p. 153)

Categories	Purchasing strategy/ scenario	Description
Strategic	Maintain a strategic partnership	Strategic commodities that have a supply risk must be controlled by building partnerships with suppliers so that sustainable production can be maintained without any obstacles to the availability of commodities.
	Accept locked-in partnership	This happens if the supplier's bargaining position is higher than the buyer.
	Terminate a partnership	If the supplier's performance can be accepted again by the buyer, the buyer must start reducing the reliance on suppliers and even stop the partnership contract and start looking for alternative suppliers.
Bottleneck	Accept dependence, reduce the negative consequences	Consider a product with a low financial value, but a high supply risk. Your company is vulnerable regarding the supply of the (single) supplier. Assurance of supply is pursued by keeping high safety stocks.
	Reduce dependence and risk, find other solutions	Consider a product with a low financial value, but a high supply risk. Your company is vulnerable regarding the supply of the (single) supplier. In response to this situation, it is decided to search for other solutions, especially by working with more generic specifications, if necessary, finding another supplier.
Leverage	Exploit buying Power	The bargaining position of the buyer is higher than the supplier so that the buyer can enter into a cooperation contract with a supplier that can provide more benefits.
	Develop a strategic partnership	If the buyer has found a supplier in accordance with the criteria, it is necessary to build a strategic partnership with suppliers to ensure supply availability and can increase the efficiency and effectiveness of the buyers.

Table 18 (continued)

Non-critical	Pool purchasing requirement	For routine commodity needs, steps need to be taken to reduce the complexity of administration and logistics, namely by establishing a system of contracts with fixed suppliers.
	Individual ordering, efficient purchasing	If the steps to build a system of contracts with suppliers cannot be done, then individual purchases can be made using a purchase card to reduce indirect costs, such as booking administration fees and billing.

In order to secure the key resources that are important for organizational performance, Schwieterman and Miller (2016) developed an action matrix called the Factor Market Rivalry (FMR), which reflects the competition over resources. It captures the different strategies implemented by purchasers to manage access to resources in a highly competitive market. The model consists of two dimensions (internal and external) on the horizontal and improving access to resources and reducing the importance of resources on the vertical. This results in four quadrants: internal resource enhancement, crafting the resource environment, internal resource replacement, and managing resource demands, as depicted in Table19.

Table 19: The FMR Action Matrix (Schwieterman & Miller, 2016, p.106)

Purpose of Action	Domain of Action	
	Internal	External
Improve resource access	**Internal Resource Enhancement** - Invest in employee training to enhance environmental scanning capabilities. - Expand the scope of competitor analysis by including more diverse managerial perspectives. - Develop an in-house capability to supply the resource (i.e., upstream or forward vertical integration). - Hold additional supplies of the resource if possible.	**Crafting the Resource Environment** - Secure long-term contracts to guarantee resource access. - Cultivate alternative sources of supply for the resource (i.e., identify alternative suppliers or distribution channels). - Work with supply chain members to improve the sustainability of the resource. - Acquire of a key resource provider.
Reduce resource importance	**Internal Resource Replacement** - Identify a more available substitute for the resource. - Alter internal processes to reduce the demand for the resource. - Diversification of products/services to reduce the importance of the customer segments that utilize the resource.	**Managing Resource Demands** - Convince customers that the products/services rendered from this resource are unnecessary. - Work with supply chain members to develop an alternative to the given resource. - Work with other parties (e.g., universities, research centres) to find an alternative to the resource.

Rozemeijer, van Weele, and Weggeman (2003) developed a matrix that consisted of five different strategies based on two factors. The purchasing maturity of an organisation was measured in terms of its function, the role and organisational status of the purchasing department, the availability of purchasing information systems, the quality of the people involved in purchasing, and the level of collaboration with suppliers. The corporate coherence, on the other hand, reflects the degree to which different organisational parts operate and manage as one entity, as any changes in the structure across business units would result in significant challenges (Rozemeijer et al., 2003). As shown in Figure 15, when both constructs are high, a centre-led structure is recommended, where the purchasing department is responsible for driving the procurement strategy and the management of supplier relationships across the organisation, while the other business units perform some of the tactical purchasing decisions, following the guidance of the purchasing department to ensure that they are aligning with the overall procurement strategy. It aims to increase transparency, improve coordination, and effectively manage risk. In contrast, if both dimensions were low, it is advisable to decentralise the purchasing process, where the purchasing team gives the full authority for all business units to process and manage their purchasing sources, unlike centralised purchasing. In centralised planning, all the decisions related to the purchasing process are made and managed by the purchasing team. Federal (or local-led) purchasing occurs where there is a high purchasing maturity. This is managed by the purchasing team by setting criteria such as the environmental standard, security clearance, and other required certifications that must be considered when selecting suppliers to ensure that they comply with government regulations and improve accountability for purchasing decisions. Finally, the purchasing team coordinates purchasing, which is in-between centralised and decentralised. At

this position, all the business units work together with the aim of determining needs and leveraging their buying power in order to achieve better negotiations with suppliers (Rozemeijer et al., 2003).

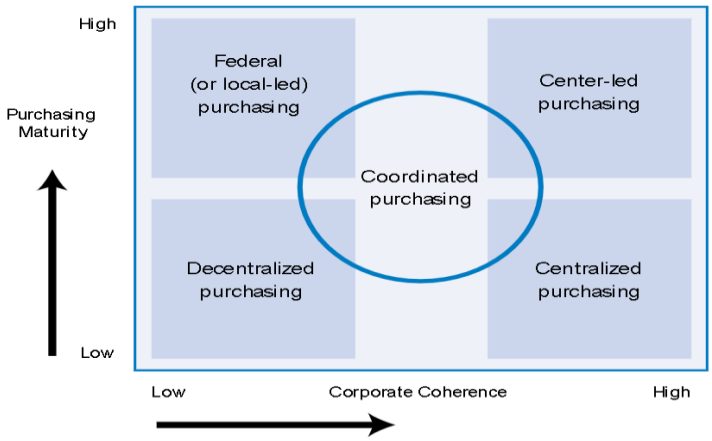

Figure 15: Corporate Purchasing Organisational Approach (Rozemeijer et al., 2003, p11)

To overcome the side effects of the COVID-19 global pandemic, vaccines have been considered as a long-term effective solution to return to normal life. Governments all over the world have been concerned about securing the vaccine for their people in order to save lives, limit the spread of the virus, and regain national economic growth. That resulted in a very high demand for COVID-19 vaccines, while initially, there was a very limited number of suppliers who had been granted emergency authorization by the World Health Organization (WHO, 2023). There were a number of factors affecting the purchasing of vaccines, which in most cases was done by the health department of each government. Some of the factors that granted countries early access to the vaccine were the fact that they had invested in vaccine research and development or that government-initiated deals had been made early in the pandemic (Teerawattananon, Botwright, & Ozturk, 2022). Therefore, governments were faced with a challenge on two different sides of purchasing: the pre- and post-buying phases. In the pre-buying phase, there were challenges related to identify needs, the selection of prequalified products and suppliers, establishing specifications and legal criteria, and preparing for bidding and evaluation. In contrast, in the post-buying phase,

there were challenges related to ensuring the availability, timeliness, safety, and performance of vaccines (Gianfredi et al., 2021).

To determine the appropriate purchasing strategy, the purchasing portfolio technique has been employed in the past, using Morocco as a case study (Benchekroun et al., 2022). The vaccine purchasing strategy was implemented in two stages. First, the study determined the criticality level of the COVID-19 vaccine using the principle of KPP. For the profit impact factor, the authors applied the following criteria as measurement variables: impact on profitability, importance of purchase, and value of purchase. Supply risk, on the other hand, was modified according to the proposed definition by Benchekroun et al. (2022) – consisting of market risk, performance risk, and complexity risk. According to the analysis result, the COVID-19 vaccine was located in the strategic quadrant, where a diversification strategy is recommended. At this point, the study moved to the second stage, where it evaluated the value of adopting a diversification strategy. The authors adopted what is known as a Sustainable Development Analytical Grid (SDAG). Its analytical technique addresses ecological, social, economic, ethical, cultural, and governance factors (Villeneuve, Tremblay, Riffon, Lanmafankpotin, & Bouchard, 2017). Each of these factors contains a number of variables, forty in total. To determine the applicability of these variables, a question was directed to the study's experts, asking their opinions on a scale of 1–3 on whether the variables were indispensable, necessary, or desirable for the success of the COVID-19 purchasing strategy. Then, a second question aimed to evaluate the performance of the diversification strategy based on the selected variables. Using a percentage scale of zero to 100 per cent (0–9% reflected the lowest impact and 90–100% the highest impact of the strategy), the experts were asked how the strategy addressed the availability of COVID-19 vaccines. The study concluded that a diversification strategy was the best for managing the purchasing of the vaccine.

The Moroccan government was relying on AstraZeneca, the delivery of which was regularly interrupted; therefore, they started slowly with Sinopharm due to the intense competitive rivalry. They then introduced Pfizer as an additional supply to diminish the power of Sinopharm (Benchekroun et al., 2022). In addition to the diversification strategy that was considered by the Moroccan government, when concluding their study, the authors discussed the other government's initiatives to manage the purchasing strategy of the COVID-19 vaccine. It used its diplomatic relationships with initial suppliers when negotiating in order to strengthen its purchasing power. It also launched in-house production for both the syringes and filling them with vaccines. On the other hand, to convince its people of the vaccine's importance, an immunization awareness campaign was carried out using different media platforms. Finally, the government managed and controlled the vaccine supply locally. One of the key strategies recommended by the OECD (2021) as a role of government in dealing with COVID-19 vaccination programmes is enhancing the public's trust. It emphasizes the importance of communication and releasing information related to the vaccination strategies, being more transparent with the public, and engaging them while developing the strategies.

Moving the position of the products, items, or suppliers is one of the model's outcome strategies. In 2002, (C. J. Gelderman & Weele, 2002) studied the movement strategies between categories by plotting the buying strengths against the strengths of the supply market. The vertical dimension was modified. Instead of testing the impact of profit, they tested the important purchasing strategies, which are:

- **The strategic importance of the purchase (Vertical):** this is assessed in terms of the value-added by product line, the percentage of purchased products as part of the total cost, and the impact on the company's profitability.

- **The supply risk (Horizontal):** measured by supply scarcity, determined by factors such as state-of-the-art technology, the complexity of the supply market, material substitution, barriers to entry, logistics, and monopoly/oligopoly conditions.

This study was the first to provide movement guidelines between the portfolio quadrants in order to reduce the risk of supply. A practical solution was provided by (Gangurde & Chavan, 2016). They were able to move most of the strategic items to the leverage quadrant, which reflected significantly on the purchasing portfolio. However, these movements can be triggered by external factors such as an increasing number of suppliers who can supply products, new technologies that reduce costs, or government regulations that cause products to become scarce (Rachman, 2019). In addition, internal factors can force movement between quadrants when there is a chance to take advantage of the ability to reach economies of scale when ordering products and when there is a possibility to standardize the required products (Rachman, 2019).

In their purchasing process, many organizations adopted the concept of a sustainable supply chain based on the Triple Bottom Line (TBL). It emphasizes the performance of profit, environment, and social activities. Regarding the purchasing portfolio, the authors have noticed that many of these organizations are treating the strategic supplier on a base of leverage direction, which might lead to inappropriate assessment (Pagell et al., 2010). Therefore, there is a need to modify the purchasing portfolio, as stated by the authors. According to that, the dependent dimension for measuring the buyer-supplier relationship has been changed to measure the TBL risk. At the same time, the independent factor remains the same, measuring the supply risk through an in-depth interview with experts in the supply chain in 10 leading industries performing the triple bottom line concept. As the study reveals, the purchasing portfolio remains unchanged in the modified model.

Non-critical quadrant occurs when both dimensions are low. A bottleneck quadrant occurs when the supply risk is high and TBL is low. Profit alone is no longer considered a risk as the manager must count the other TBL elements: the environment and society; therefore, a slight change in the strategic quadrant occurs. A significant change in the leveraged quadrant has been identified. The leverage quadrant became three different layers within the leverage quadrant since the profit is not the only aspect to be considered. The true commodity is close to the non-critical quadrant when the supply risk is low while one of the TBL elements is affected. Traditionally, the purchasing portfolio only considered the price without the environment and society. At the true commodity level, the price is the only factor affected. If two elements of the TBL are affected, and the supply risk remains low, the buyer-supplier relationship would move to the transitional commodity. Unlike the true commodity, managing the relationship at this level is difficult. Suppliers will be treated as strategic suppliers. Thus, the authors found that transition considers a key succession to avoid unnecessary costs. The final level that is close to the strategic quadrant is the strategic commodity level, where the supply risk is slightly high and more than one TBL element is high. It reflects the importance of the assessed item, which is beyond simple market economics, putting it at an advantage in the long term (Pagell et al., 2010). The study highlights an important aspect of today's economy that many organizations consider, the sustainable supply chain. However, due to the comparison between the traditional portfolio and the authors' proposed model, it would be better to compare both using a practical case study before and after adopting the portfolio.

2.6 Conclusion

This study aims to manage the national strategic reserve by classifying critical intermediate and final products and identifying appropriate criteria for determining the products' criticality on

a national basis. Through the literature review, identifying the research gap and questions are discussed in the following sections.

2.6.1 Research Gap and Questions

Strategic sourcing was found to be covered by several models and studies. However, there have been no studies identified so far that have covered the gap between the strategic reserve and strategic sourcing in terms of managing or classifying the intermediate and final products, especially on the national level. To answer the main research question, which is *how to determine the importance level of the critical intermediate and final products that need to be strategically reserved?* It can be articulated through the following three research questions that fill in research gaps, as shown in Table 20.

Table 20: Research Gap

Overarching Research Question	**Overall Research Gaps**
How to determine the importance level of the critical intermediate and final products that need to be strategically reserved?	Lack of theoretical framework and empirical work regarding the national strategic reserve in the field of strategic sourcing.
Sub Research Questions	**Research Gap**
1. What are the most significant variables that determine the level of importance of critical intermediate and final products at the national level in Saudi Arabia?	Lack of measurement variables that determine the level of intermediate and final product criticality on a national basis for both dimensions.
2. The literature review has revealed that there is a lack of studies determining the criticality level of intermediate and final products on a national basis. Based on the concept of a purchasing portfolio, on a national basis, how critical are rice, gasoline, semiconductors, and insulin in Saudi Arabia? This question is answered through the following sub-questions: 2.1 The Ministry of Environment Water and Agriculture in Saudi Arabia listed rice as one of the strategic products; how likely its true, based on the purchasing portfolio principles?	To the best of the researcher's knowledge: - Up to this date, the model has not been applied in the context of managing the national strategic reserve for critical intermediate and final products. - There is no study that combined between PEST factors and purchasing portfolio in terms of classifying the critical intermediate and final products on a national basis.

Table 20 (continued)

2.2 Based on the purchasing portfolio principle, is gasoline considered to be a strategic product in the country with the largest crude oil producer, Saudi Arabia? 2.3 Insulin is a life saver for people with diabetes. Based on the purchasing portfolio viewpoint, what is the status of insulin in Saudi Arabia? 2.4 The United States of America and China are competing on semiconductors products. Based on the purchasing portfolio principles, what is the criticality level of semiconductors in Saudi Arabia?	- No study tested these products (rice, gasoline, semiconductors, and insulin) on the national level using the purchasing portfolio model. - No study answered these questions in the literature.
3. What are the key strategic recommendations that could be considered by policymakers to manage critical intermediate and final products on a national level in Saudi Arabia?	To the best of the researcher's knowledge, up to this date no study recommends a strategic action on national basis linked them with the purchasing portfolio quadrants.

To the best of the researcher's knowledge, no study to date has answered these research questions for this particular type of product (intermediate and final products) in the context of the national strategic reserve. This gap has been reflected in reality by the shortage issue that has emerged during the past two years of conducting this research. Being part of the supply chain community, it is very important to apply our theories and practices to serve the community and ensure the nation's sustainability and stability. Identifying the critical product on a national basis that needs to be reserved will contribute to solving an important issue related to national stability and sustainability. By identifying the critical intermediated and final products, the government administration can ensure the continuity of supply flow for critical products, address the reasons behind the shortage, and work to solve the issue as much as possible, to reduce the shock that might occur due to the shortage.

The concept of the strategic reserve has been associated with specific types of products that represent a nation's need for sustainability and growth. Many studies have focused on the

mechanism of handling strategic reserves, i.e., how and for how long to store products such as grains, water, oil, national currency, and major medicine. Most scholars concentrate mainly on the history, size, time of release, and efficiency of the strategic reserve (Liao et al., 2016). Attention has been given to the possibility of sharing responsibility for the strategic reserve with the private sector; this is known as the Public-Private Partnership (PPP). This is especially the case in grains studies and critical raw materials (Calvino, 2022; Shukla et al., 2014; World Bank Group, 2016).

The concept of a purchasing portfolio has been used extensively since it was published in 1983 by Peter Kraljic in his article "Purchasing Must Become Supply Management." This tool was the first to bring portfolio models into the purchasing area (C. Gelderman, 2022). The model's main concern is about classifying the importance level of the object that is being tested, which leads to better managing the resources. To the best of the researcher's knowledge, the model has not been applied on similar study's context and types of products. Therefore, understanding the model in different settings will add additional aspects to the concept of purchasing portfolio.

2.6.2 Study Dimensions

Through a critical analysis of the literature related to holding strategic reserves at a national level, five key themes/factors have been identified that affect the criticality level of intermediate and final products. These are the causal factor (independent), which is the supply risk, and the main impacted four factors, namely the PEST factors (dependent). Both types of factors shape the quest of this research and contain a measurement variable that has been extracted from the literature and verified and confirmed by experts, as illustrated in the following chapter.

I Independent factor Supply Risk – (X)

As with all other aspects and fields, risk in supply chains can occur at any point of their dynamic, interconnected stages during the sourcing, operations, or logistics. The term ‘risk’ was defined as the possibility that an event could occur due to the known probability that it would lead to undesirable results (Rutherford, 2002). Supply risk means uncertainty of supply (Guo et al., 2020). Heckmann et al. (2015, p.130) defined the concept of supply chain risk as “the potential loss for a supply chain in terms of its target values of efficiency and effectiveness evoked by uncertain developments of supply chain characteristics whose changes were caused by the occurrence of triggering-events”.

In the field of procurement, Zsidisin (2003) defines the supply chain risk in purchasing as the probability of an incident associated with inbound supply occurring as a result of failures with an individual supplier or the supply market. This results in the purchasing firm being unable to meet customer demand or threats to customer life and safety (p. 222). Supply chain risk measures the ability of the supplier to deliver the required product in the required quantity and by the required date (Chou & Chang, 2008). Hinson and McCue (2004) view supply risk as the degree to which goods and services present a risk or are critical to the organisation. Therefore, assessing the risk is indisputable and the failure to identify and evaluate the potential risk riskier (Faisal, 2009). The source of risk can be categorised into two main categories: internal and external (Faisal, 2009; Manners-Bell, 2014).

Internal risk is a weakness that originates from the project host itself in terms of implemented policy and procedures, capabilities, information flow, structure, and the behaviour of the internal project environment (Barber, 2005). Following Barbra’s definition, it is essential to

understand and assess internal risk in terms of the capabilities; these include the availability of required sources and materials and ensuring good management practices are enforced to manage communication between supply chain tiers, inventory, quality standards, and operational and logistical aspects. On the other hand, external risks refer to threats and uncertainties that originated from an external source that disrupts the supply flow of required products or materials. They are unpredictable and beyond the supply chain stakeholder's control (Faisal, 2009; Manners-Bell, 2014; Salamai, Hussain, Saberi, Chang, & Hussain, 2019). Often, they are grouped into five categories: environmental, economic, security, societal, and technological. The environmental threats include climate change, pandemics, and natural disasters. Economic threats include inflation, recession, and supply and demand shocks. Security threats include the flow of supply, and this includes a geopolitical aspect – for example, shutting down the Straits of Hurmuz, through which passes much of the world's oil supply, due to the sanctions against Iran (Manners-Bell, 2014). In addition, the security threats include disruptions in product flow due to corruption, cargo crime, and piracy. Step aside, ignoring and not considering social responsibility, which is considered an external threat to the flow of supply. When companies take advantage of low-cost labour, due to a lack of environmental regulations, by using young workers, etc., that affects the reputations of the suppliers, which in turn affects the flow of supply (Manners-Bell, 2014). Finally, the technology threat (Manners-Bell, 2014; Urciuoli, Männistö, Hintsa, & Khan, 2013). Soon after COVID-19 in 2021, one of the major gasoline and jet fuel pipelines had to shut down as it was hacked, affecting the fuel supply for the eastern region of the United States of America (Katagiri, 2023).

In a supply chain, internal and external risks are strongly interconnected (Faisal, 2009; Urciuoli et al., 2013). According to the level of reliance, if one node affects the remaining nodes

in the chain, they will be impacted on different levels; therefore, different methods and techniques are proposed in the literature to evaluate suppliers in all the tiers of the product supply chain (Faisal, 2009).

According to Faisal (2009), risks in supply can be classified into four main categories that combine internal and external risks: physical, financial, relational, and informational risks. Physical risks are related to the routine processes of the product supply flow, which are difficult to anticipate. They can take the form of delays, disruption, lack of supplier capacity, production technology changes, transportation, mismanagement of inventory, procurement, lack of flexibility to adapt or meet demand, product design and quality. Financial risk which is an uneasy task, particularly when dealing with different suppliers in different parts of the world. These risks include fluctuations, currency and price changes, changing labour costs and economic structure in other key suppliers' countries, settlement process disruption, and untimely payments. Relationships between supply chain members are considered one of the keys to success in supply chain networks. They are built on trust and mutual benefit. Buyers are concerned about their suppliers' strengths as well as their profit margins and vice versa. One of the famous strategies employed by supply chain parties is known as a win-win relationship, where all parties collaborate to maximise each other's benefits; this results in a long sustainable relationship. Any error in this relationship might be called relational risk. Finally, informational risk can arise from incomplete, inaccurate, or misleading information shared between supply chain members at any point in the supply chain. It includes a lack of visibility, cybersecurity, and inaccurate forecasting (Faisal, 2009).

Supply risk factors have been used widely in the literature in different models and techniques to identify and mitigate risk in supply; however, based on the nature and scope of this

study, the variables that measure the level of risk of critical intermediate and final products need to be explored and verified; this is one of the aims of this research. To meet the objective of this study, both the casual factor supply risk and its effect on the PEST factors in this study are discussed in chapter four.

II Dependent factor (PEST) – (Y)

As stated earlier, PEST stands for political, economic, sociocultural, and technological. On a national basis, shortages in critical products threaten the stability of these factors. As mentioned earlier, in Egypt, such shortages increased food prices, which contributed to a revolution known as Arab Spring in 2011 (Breisinger et al., 2014). The need to hold a strategic reserve in order to maintain a robust national economy has been demonstrated in many countries; a notable example is the petroleum reserves in the US, China, and India (Biswa, 2020; Guo et al., 2020; Ogden, 2019). The attitude of society can also be impacted by shortages due to a lack of income, food, and services (ESCWA, 2020), causing sociocultural issues. Most criticality studies have focused on securing the future of technology and national innovation by identifying critical raw materials and ensuring the stability of their supply. The literature review of criticality studies and strategic reserves revealed the main themes of politics, the economy, sociocultural values, and technology. These themes were confirmed by the qualitative research conducted in this study, as can be seen in the results section. A remarkable point here is that the outcome factors of holding a strategic reserve on a national basis match one of the strategic analysis tools, PEST analysis, which was introduced by Francis Aguilar in 1967 (Vasileva, 2018).

To measure the stability of a nation, firms tend to use the PEST analysis technique. It is used as a national macro-environment measurement tool to understand the opportunities or risks in the environment in which the PEST analysis is being conducted (G. Johnson & Scholes, 2001;

PHAST, 2017; Tasios, 2018; Warner, 2010). They are considered key elements of gaining a good understanding of the local market and ensuring its stability and sustainability (Briguglio, Cordina, Farrugia, & Vella, 2009). PEST analysis is considered to be "A useful tool in the study of factors influencing the development of territorial communities of different ranks and scale" (Vasileva, 2018, p. 223). Accordingly, in this study, the PEST factors are considered dependent factors when exposed to supply risks, the independent factor that threatens national stability due to the lack of availability of critical intermediate and final products in Saudi Arabia's market. The model has been used widely in different fields of studies conducted on a national level (see, for example, Barbara, Cortis, Perotti, Sammut, & Vella, 2017; Chao, Peng, & Nunes, 2007; Ha & Coghill, 2006; Idris, 2018).

The political (P) factor describes changes in the role of government and how this could be impacted by the changes that might occur due to a shortage of significant products (R. J. Chapman, 2011; Panagiotou, 2013; Sammut-Bonnici & Galea, 2015; Warner, 2010). Some analyses include legal developments as a natural part of the political assessment (PHAST, 2017; Warner, 2010). The economic (E) factor describes those macroeconomic aspects that can be used to make an assessment of the state of the economy and practical ways to improve its performance in order to ensure economic growth, price stability, and full employment of the labour force, and to keep interest rates, inflation and production at acceptable level (R. J. Chapman, 2011; Panagiotou, 2013; Sammut-Bonnici & Galea, 2015; Warner, 2010). The sociocultural (S) factor addresses changes in the social structure such as age, gender, beliefs, values, health, education, green practices, consumer behaviour, and demographics (Ben Hassen, El Bilali, & Allahyari, 2020; R. J. Chapman, 2011; Panagiotou, 2013; Warner, 2010). In regard to the environmental aspect, some analyses include it as part of the sociocultural assessment (PHAST, 2017; Warner, 2010). The technological

(T) factor refers to innovation, the world wide web, and robotics and how their absence might affect the future of technology, production, and innovation (R. J. Chapman, 2011; Panagiotou, 2013; Warner, 2010).

III Model Categories

For this study, the label of the categories has been kept as it was proposed by Kraljic (1983), which provides an appropriate indication for the decision-maker. The strategic level occurs when the level of PEST and supply risk impact is high. A non-critical occurs when the level of both dimensions is low. The bottleneck occurs when the level of supply risk is high and the level of PEST impact is low. Finally, leverage occurs when the level of PEST impact is high and the level of supply risk is low.

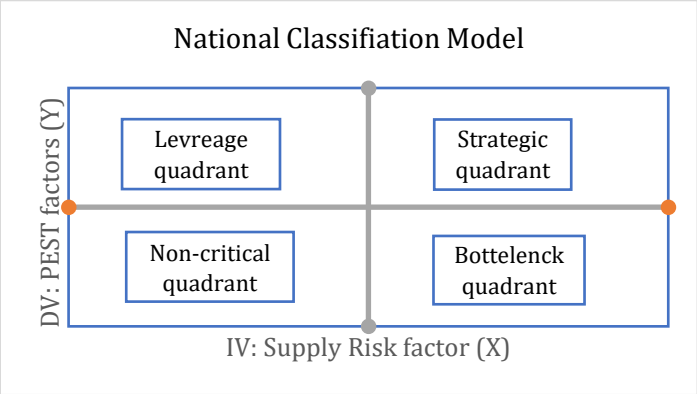

Figure 16: Proposed Model

1. **The strategic quadrant** occurs when the level of PEST and supply risk impact is high. Any intermediate and final products classified inside of this quadrant usually have a very limited source of supply; at the same time, the absence of a product has a high level of impact on politics, the economy, the sociocultural, or technology.

2. **The bottleneck quadrant** occurs when the level of supply risk is high and the level of the PEST impact is low. It represents a relatively limited value in terms of politics, economy, sociocultural, and technology but is vulnerable with regard to supply.
3. **Leverage quadrant** occurs when the level of PEST impact is high and the level of supply risk is low. On organizational level, this is the most favourable quadrant where the risk in supply flow is low due to either the local availability of the product or the number of available suppliers all over the world (Rachman, 2019).
4. **Non-critical quadrant** occurs when the level of both dimensions is low. Although the product is critical; however, there is an abundance of the product in the local market.

Chapter 3: Research Design

3.1 Introduction

The aim of this research is to generate new knowledge in the field of purchasing that is based on reliable evidence. Reliable evidence must be based on a scientific foundation, which is created through the research design. This is the framework that guides the collection and analysis of reliable data (Pandey & Pandey, 2015). This chapter details the research philosophy adopted to conduct this research. It illustrates the approaches and instruments utilised in this mixed-method research to achieve the objective of the research. The chapter presents the process of collecting the data and recruiting the study sample. In addition, the analysis techniques that are implemented for this research are presented and discussed.

In order to cover the identified gap in the literature and fulfil the academic purposes of this study, a mixed-method research approach was determined to be the most suitable approach to pursue. The study follows the exploratory sequential design, which starts by exploring a topic with a small qualitative sample. Then it builds the quantitative feature, such as a survey or instrument, new variables, or a website, which is tested quantitively (Creswell & Clark, 2017). A key step of this design is connecting this with the result of a qualitative approach (Creswell & Clark, 2017). The qualitative method is used in this study to answer the first research question, which aims to verify the model variables of each dimension, and determine whether to add, remove, or edit them. It answers the first and third research questions, whereas the quantitative method aims to answer the second research question, as listed below:

1. What are the most significant variables that determine the level of importance of critical intermediate and final products at the national level in Saudi Arabia?

2. The literature review has revealed that there is a lack of studies determining the criticality level of intermediate and final products on a national basis. Based on the concept of a purchasing portfolio, on a national basis, how critical are rice, gasoline, semiconductors, and insulin in Saudi Arabia? This question is answered through the following sub-questions:
    2.1 The Ministry of Environment Water and Agriculture in Saudi Arabia listed rice as one of the strategic products; how likely its true, based on the purchasing portfolio principles?
    2.2 Based on the purchasing portfolio principle, is gasoline considered to be a strategic product in the country with the largest crude oil producer, Saudi Arabia?
    2.3 Insulin is a life saver for people with diabetes. Based on the purchasing portfolio viewpoint, what is the status of insulin in Saudi Arabia?
    2.4 The United States of America and China are competing on semiconductors products. Based on the purchasing portfolio principles, what is the criticality level of semiconductors in Saudi Arabia?
3. What are the key strategic recommendations that could be considered by policymakers to manage critical intermediate and final products on a national level in Saudi Arabia?

Byrne (2018) mentioned four reasons for conducting research: solving a new or existing problem; reassessing the results of previous studies; investigating; and either supporting or developing theories. This research uses a scientific method to produce evidence and findings that do not depend on the researcher's personal views (Byrne, 2018). Therefore, it is essential to design a research study since there needs to be a logical sequence that connects the data to the initial research questions and, ultimately, its conclusions (J. W. Creswell, 1998). The most common

research assumptions are ontology and epistemology (M. N. K. Saunders, Lewis, & Thornhill, 2019).

Ontology

Ontology is concerned with reality, what it is, how it is formed, the factors behind it, and how they interact with each other. It is defined as the nature of reality, whether if it exists independently of human perception or socially constructed (Collis & Hussey, 2014; M. N. K. Saunders et al., 2019). Therefore, it guides the researcher to understand the nature of the phenomena being studied. For this study, the reality is socially constructed, which leads to questions such as: what makes a product become critical on a national level? What are the reasons for holding a national strategic reserve for certain types of products? What type of knowledge exists related to the criticality level of intermediate and final products, and how are they managed? Does knowledge about reality exist objectively or subjectively? (Collis & Hussey, 2014; M. N. K. Saunders et al., 2019). The objective in ontology is to study the phenomenon as it is in reality, without a subjective intervention, independent from individual cognition. This contrast with the subjective approach, where the researcher understands the phenomenon based on the point of view of those who have knowledge of the phenomenon being studied (Collis & Hussey, 2014; M. N. K. Saunders et al., 2019). It shapes the way in which researchers see and study their research objects (M. N. K. Saunders et al., 2019). In terms of identifying the criticality level of intermediate and final products, there is a need for both subjective (qualitative) and objective (quantitative) ontological approaches in this research.

Epistemology

This refers to the assumptions that determine acceptable, valid and logical knowledge and how we can communicate knowledge to others (Collis & Hussey, 2014; M. N. K. Saunders et al., 2019). Through epistemology, the researcher can scientifically answer the following questions that establish what is known about the phenomenon being studied and contribute to knowledge in the field. How can we know what we know? What is considered acceptable knowledge? What constitutes good-quality data? And what kind of contribution to knowledge can be made? (Saunders et al., 2019, p. 135). As with ontology, in epistemology, objectivism seeks to explore reality through measurable facts and numbers, while subjectivism explores reality through opinions, which include narrative and story data (M. N. K. Saunders et al., 2019).

Most research questions can be answered through qualitative, quantitative or mixed methods. Therefore, when selecting the research methods, an essential element is the choice of an appropriate assumption. Since the literature review did not clearly identify the variables that would help to identify and classify the criticality of intermediate and final products, a qualitative research method was selected to conduct an exploratory investigation of the scope of this study from different viewpoints. Accordingly, the data from this investigation became the basis of the national classification model, which is tested by using a quantitative method.

The design of the research study enables the researcher to better understand and address the research questions (M. N. K. Saunders et al., 2019). This is because the design constitutes a credible research philosophy that underpins the researcher's choice of method, the research strategy, and the data collection techniques and analysis procedures (M. N. K. Saunders et al.,

2019). It is guided by many factors, such as the objective and the research question. The following flowchart illustrates the sequence of the research strategy of this study.

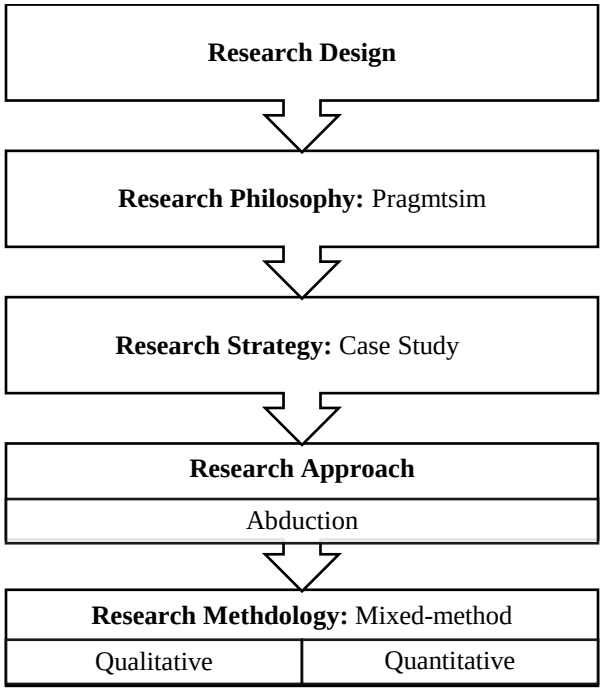

Figure 17: Research Strategy Sequence

3.2 Research Philosophy

The research philosophy refers to the beliefs and assumptions about knowledge development (M. N. K. Saunders et al., 2019). When determining the appropriate manner to study the phenomena, the use of both qualitative and quantitative methods provides a clear picture and understanding of the phenomena under investigation. It guides the researcher to the appropriate method to explore, understand, and explain the phenomena being studied. To achieve the purpose of this study and to ensure the effectiveness of the model in determining the criticality level of intermediate and final products, this study employs mixed-method research. There are two phases: a literature review and a qualitative study, followed by the implementation phase, which employs

a quantitative approach. Based on the ontological position of this research, pragmatism philosophy is the most appropriate as it is aligned with the objective of this research.

The pragmatism philosophy was introduced by Charles S. Peirce in his 1878 article entitled, “How to make our ideas clear?” (James, 1907). However, after having been overlooked for 20 years, the philosopher William James resurrected it in 1898. The core of the pragmatism philosophy is ensuring the clarity of the idea that was generated directly by practices and indirectly by feelings (James, 1907). Pragmatism philosophy is a practical scientific philosophy that does not only build on the cogitative approach; this makes it different from other philosophies. Pragmatism philosophy allows the researcher to use appropriate methods to collect the required data and answer the research questions. It is the primary philosophy for a mixed-method strategy (Charmaz, 2014).

The framework of pragmatism emphasises the practical consequences of knowledge and the importance of testing ideas in practice. In the context of a purchasing portfolio, pragmatism can be applied to guide policymakers and to develop a strategy that maximises the value of the product being procured. The model starts by identifying the root of the problem and then guiding the decision-maker towards the appropriate solution by offering pragmatic advice (Kraljic, 1983). Based on two dimensions, supply risk and profit impact, four quadrants are built. These prioritise and guide policymakers to develop appropriate strategies to secure the product being tested. It is a data-driven decision-making model, as it encourages researchers to collect and analyse data related to critical products. These may be reserved strategically at a national level, for example, raw materials, qualified personnel, market conditions, and their impact on PEST factors. Finally, based on the product’s position in the matrix, the model provides a framework that can be adapted to suit the specific needs and circumstances of the organisation or, in the case of this research, the nation.

3.3 Research Strategy

Since the nature of this research study is exploratory, the use of a case study is the most suitable strategy. It is a method of studying a phenomenon intensively over time within its natural setting at one or several sites (Bhattacherjee, 2012: p.93). Different types of methods can be used to collect the required data about the phenomenon being studied, such as interviews, observations, pre-recorded documents, and secondary data (Bhattacherjee, 2012). Case research can be employed in a quantitative study to test a theory or in qualitative research to build a theory (Bhattacherjee, 2012). The case is a bounded entity, which could be a person, organisation, behaviour, condition, event, or another social phenomenon (Yin, 2012). It serves as the primary unit of analysis in a case study, which could include other units embedded within the main case (Yin, 2012). There are four types of case study designs: a single holistic case study; multiple sub-case studies within the holistic case; multiple holistic case studies; and multiple sub-case studies within multiple holistic case studies (Yin, 2012).

To understand why certain types of products are considered critical and need to be held as a strategic reserve in Saudi Arabia, a single holistic case study with multiple sub-cases was the best design. The holistic case study was used as exploratory research to discover the relevant features, factors or issues that may apply (Dul & Hak, 2008). Therefore, it was implemented for the first phase of this study. For the second phase of this study, four sub-cases were embedded within a holistic case study: these were rice, insulin, gasoline, and semiconductors product. The aim was to test the model quantitatively. Table 21 illustrates the case study protocol for this research, followed by a justification for the selection of the case studies.

Table 21: Qualitative and Quantitative Case Study Protocol

	Phase 1: Qualitative	Phase 2: Quantitative
Aim	Identify and validate the measurement variables for both supply risk and PEST that are applicable to the importance level of intermediate and final products by understanding why strategic reserves are held in Saudi Arabia for certain types of products. In addition, it recommends strategic action to mitigate and manage critical products.	- Test the selected measurement variables. - Test the relationship between supply risks and PEST factors in terms of determining the criticality of intermediate and final products. - Determine the criticality level of rice, insulin, gasoline, and semiconductors (test the model quantitatively).
Research questions	1. What are the most significant variables that determine the level of importance of critical intermediate and final products at the national level in Saudi Arabia? 3. What are the key strategic recommendations that could be considered by policymakers to manage critical intermediate and final products on a national level in Saudi Arabia?	2. The literature review has revealed that there is a lack of studies determining the criticality level of intermediate and final products on a national basis. Based on the concept of a purchasing portfolio, on a national basis, how critical are rice, gasoline, semiconductors, and insulin in Saudi Arabia? This question is answered through the following sub-questions: 2.1 The Ministry of Environment Water and Agriculture in Saudi Arabia listed rice as one of the strategic products; how likely its true, based on the purchasing portfolio principles? 2.2 Based on the purchasing portfolio principle, is gasoline considered to be a strategic product in the country with the largest crude oil producer, Saudi Arabia? 2.3 Insulin is a life saver for people with diabetes. Based on the purchasing portfolio viewpoint, what is the status of insulin in Saudi Arabia? 2.4 The United States of America and China are competing on semiconductors products. Based on the purchasing portfolio principles, what is the criticality level of semiconductors in Saudi Arabia?
The unit of analysis	PEST factors and supply risk factors	Type of product being tested: rice, gasoline, insulin, and semiconductors
Interview questions strategy	Semi-structured interviews	Online questionnaire

3.3.1 The Rational of Selected Case Studies

In this section, the justification behind selecting the case studies of this research is presented. It starts with the holistic case study, which in this research is Saudi Arabia. It then moves to discuss the sub-case studies which are rice, gasoline, semiconductors, and insulin.

I The Holistic Case Study (National Strategic Reserves in Saudi Arabia)

The Kingdom of Saudi Arabia is located in the western region of Asia (see Figure 18). It is the largest Arabian country in the region, with approximately 2 million square kilometres of land (Al-Ibrahim, 1990; OPEC, 2022). As of 2021, the population of Saudi Arabia had reached 34 million (Saudi General Authority for Statistics, 2022). The Red Sea borders Saudi Arabia to the west, while the Gulf, Qatar, and the United Arab Emirates border it to the east. The kingdom is bordered by Kuwait, Iraq and Jordan to the north, and the south side is bordered by the Republic of Yemen and Oman (GAS, 2022; OPEC, 2022). There are 13 administrative regions distributed among the kingdom's five parts (GAS, 2022). Each region has specific characteristics and capabilities. The central region is where the capital city Riyadh is located, and the holy cities Makkah and Madina are in the western region (MOI, 2022a, 2022b). Damam and Al-Ahsa are situated in the eastern region, where the largest oil fields are located (Kultgen, 2014; X. Li & Molina, 2014). The northern and southern regions are characterised by their nature and chilly weather (M. A. Abdullah & Al-Mazroui, 1998; MOI, 2022b).

Figure 18: Saudia Arabia Map (Wikimedia, 2023)

Saudi Arabia is known for its intense summer temperature that may exceed 48 degrees Celsius (AlDuwais, 1983; El-Shaarawit & Al-Masri, 1996); however, in some regions, the weather reaches temperatures below freezing point (El-Shaarawit & Al-Masri, 1996). In general, Saudi Arabia's climate can be described as a semi-arid to dry desert with hot days and cold nights and very low annual rainfall (National Centre of Meteorology, 2022). Rainfall is very sporadic in Saudi Arabia. The north and central parts receive rainfall during the winter, while the southwestern region (El-Shaarawit & Al-Masri, 1996; National Center of Meteorology, 2022). To conclude, weather conditions in these regions make growing plants that satisfy local needs extremely difficult (Baig et al., 2022).

The land of Saudi Arabia is not only rich with oil wells; the desert contains a great abundance of natural resources that are critical in today's modern world (for example, gold, silver, platinum, uranium, copper, feldspar, phosphate and more) (OPEC, 2022). However, it lacks one of the most important elements, that is water (Al-Ibrahim, 1990; Baig, Alotibi, Straquadine, & Alataway, 2020; Ouda, 2014). As a consequence, there is a lack of agriculture (AlDuwais, 1983; Baig et al., 2022).

The concept of strategic reserves in Saudi Arabia is not odd. Securing food, water, major medicine, and energy was always at the top of government priorities. As mentioned above, the country suffers from a serious lack of one of the important natural resources, water (Al-Ibrahim, 1990; Reig, Maddocks, & Gassert, 2013). Four main sources of water are available in Saudi Arabia – surface water, groundwater, desalinated water and treated wastewater – while rivers and lakes are scarce (Al-Ibrahim, 1990; Baig, Alotibi, Straquadine, & Alataway, 2020). To mitigate this, the Saudi government has built 35 desalination plants providing 50% of Saudi Arabia's drinking water (Baig, Alotibi, Straquadine, & Alataway, 2020; Chandrasekharam, 2018). The world's largest water desalination producer is located there (Baig, Alotibi, Straquadine, & Alataway, 2020; MEWA, 2021). Therefore, the government considers desalination plants as a strategic water source, but they require a great amount of energy to operate (Ouda, 2014). Baig et al. (2020) reported that it is an unsustainable and costly source depending on the oil market. In addition, in 2020, the total capacity of tank reservoirs was over 43 million cubic metres in different locations, which is required to meet citizens' urgent needs (MEWA, 2021). The government plans to increase the storage capacity and, in turn, extend the supply period (MEWA, 2020a). Dams are a reserve solution. Based on the last annual report of the Ministry of the Environment, Water and Agriculture, there are 574 dams with a total capacity of 2.59 billion cubic metres all over the kingdom (MEWA, 2021). To preserve the groundwater, in addition to the wheat cultivation policy in 2012, in 2019, a policy was introduced that prohibited the cultivation of all types of cereals in Saudi Arabia, saving 8 billion cubic metres of water (MEWA, 2019).

Eighty per cent of the food required by residents in Saudi Arabia is imported (Baig et al., 2022). Therefore, the government of Saudi Arabia has implemented a number of programmes to govern the flow of food supplies (Ouda, 2014). On May 9, 1972, the government of Saudi Arabia

created the Saudi Grains Organisation, which was mainly concerned with sourcing and holding a strategic reserve of grains in Saudi Arabia (Royal Court, 1972). During 2020, grain reserves reached 3.5 million tons. Approximately 2.71 million tons were distributed strategically among 15 silos in different cities, and around 745 thousand tons were stored by the private sector. The year of 2020 and 2021 witnessed a huge impact on most supply chain commodities due to COVID-19 pandemic. The Agricultural Development Fund established a programme with a total amount of 2 billion Saudi Riyal, targeting food investors, especially those dealing in one of the following commodities: rice, sugar, soybean, yellow corn, beef and cooking oil (MEWA, 2022). The programme aimed to support them financially to ensure that their importation capabilities met the required quantity. In addition, a rural development (Reef) programme is targeting local small farmers in Saudi Arabia (MEWA, 2020b).

Saudi Arabia is surrounded by wars and conflicts, which means that it is in an unstable region (Alam, 2006). It is constantly threatened by Iran and ISIS, wars along the north and south borders (Syria and Yemen), the constant battle between Palestinians and Israelis, and the effects of the Arab Spring revolution (Vietor & Sheldahl-Thomason, 2018). As a precautionary measure, the government of Saudi Arabia started planning to hold a strategic oil reserve, known as the Saudi Strategic Storage Program (SSSP), during the early 1980s (Johanson & Johanson, 2004). Such a project strengthened the reliability of Saudi Arabia as the most significant oil supplier during emergencies while protecting its economy, as oil represents more than 50% of its income (AlSoud, 2019).

In 2017, the kingdom announced its 2030 Vision, which is a road map consisting of a number of programmes in different fields, all of which contribute to the security and stability of the kingdom and its economic, health, education, industrial and technological growth. Ensuring

the sustainability of vital resources and critical products is one of the core strategic aims of the 2030 Vision (Saudi Vision 2030, 2017). Therefore, the proposed model contributes to the kingdom's vision by determining the type of product that needs to be secured from the supply chain point of view.

(1) Rice Sub-case

Rice is one of the top three essential cereal crops serving as a stable food in many different cultures (Alamri, Reed, & Saghaian, 2020; T. Zhang et al., 2012). In Saudi Arabia, it is considered one of the highest-demand products as most Saudi families consume it as part of their daily meals (Alamri et al., 2020; Mousa & Ford, 2021). They use it on different occasions and at various events as part of their culture and tradition to show generosity and respect to the hosted guest (Alamri et al., 2020; Mousa & Ford, 2021). Although it is challenging to farm rice in Saudi Arabia, there is a region in the east of the kingdom called Al-Ahsa, which produces one of the highest quality rice grains worldwide, known as Al-Hassawi or Hassawi rice (Al-Turki & Basahi, 2015). It is considered one of the healthiest types of rice as it reduces the risk of type 2 diabetes (Al-Mssallem, Hampton, Frost, & Brown, 2011; Al-Turki & Basahi, 2015). However, due to the climate and water conditions in Saudi Arabia, it is a challenge to grow an amount of rice that satisfies local needs; therefore, Saudi Arabia is the third biggest importer of rice worldwide (Alamri et al., 2020; Al-Turki & Basahi, 2015).

To satisfy the large demand in the market, Saudi Arabia relies heavily on external suppliers (Alamri et al., 2020; Mousa & Ford, 2021). According to Trade Map, the total value of rice imported into Saudi Arabia in 2021 was US$1,087,307,000, which equals 882,013 tons (International Trade Centre, 2022b). It is ranked as the third-highest importer country of rice after

China and the Philippines and before the United States of America. That indicates how much rice is demanded. The population of Saudi Arabia is a little over 34 million (Saudi General Authority for Statistics, 2022), while in the USA, it is 332 million, ten times as many (U.S. Census Bureau, 2022). To satisfy the country's needs in 2021, Saudi Arabia secured its rice supply from the 13 largest rice suppliers in different parts of the world (International Trade Centre, 2022a; Mousa & Ford, 2021).

Given the importance of rice products in Saudi Arabia, the government has been keen to ensure the continuity of the supply flow without interruption. After the COVID-19 lockdown in 2020, the government of Saudi Arabia took the initiative to fund import agents for the purchasing of rice, sugar, corn and soybean to ensure supply continuity as part of the food security project (MEWA, 2022; Mousa & Ford, 2021). The question now is, what will the market of Saudi Arabia look like if it runs out of rice? Based on the purchasing portfolio analysis, would the Ministry of Environment, Water and Agriculture (MEWA) list it as a strategic product?

(2) Gasoline Sub-case

1935 was a remarkable year in Saudi Arabian history, as it was the year when oil drilling first began (Barger & Lippman, 2007; Kultgen, 2014). Soon after, in 1939, the first commercial tanker of oil was exported. The oil came from well No. 7, which is called the "Prosperity Well" (Barger & Lippman, 2007). The 1940s witnessed major changes. It saw the birth of one of the leading companies all over the world – the Arabian American Oil Company or Aramco (Barger & Lippman, 2007; Kultgen, 2014), 100% owned by the government of Saudi Arabia (Kultgen, 2014). The production capacity increased rapidly until it reached millions of barrels a year and nearly 12 million a day (Christodoulides et al., 2022; EIA, 2021a). Aramco is considered one of the largest

and most reliable suppliers of oil across the world (Guo et al., 2020; Kultgen, 2014). Therefore, Saudi Arabia's economy became dependent on oil (Alyousef & Aljarrah, 2012). In 2021, 53% of the national revenue was generated by the oil sector, with total of US$110 billion (EIA, 2021a; Saudi Ministry of Finance, 2021). Therefore, to ensure the stability of the national economy as well as the global oil market, the kingdom has the largest strategic oil reserve in the world (Sarrakh, Renukappa, Suresh, & Mushatat, 2020).

One crude oil product is gasoline (M. Al-Sahlawi, Miah, & Al-Titi, 2018; EIA, 2021b; X. Li & Molina, 2014). The United States energy information administration defines it as a fuel that is produced using crude oil and other petroleum liquids for the purpose of fuelling motors and other spark ignition engines (EIA, 2021b). Although Saudi Arabia is the largest crude oil producer and exporter (M. A. Al-Sahlawi, 1997; Alyousef & Aljarrah, 2012; EIA, 2021a; Mikayilov, Joutz, & Hasanov, 2019), it imports gasoline to satisfy its local market needs in certain periods, mostly during summer and the pilgrimage seasons (AlSaga, 2018). In addition, the lack of other energy options, such as electric cars or those fuelled by diesel, positively affects the demand for gasoline (Al-Sahlawi, Miah, & Al-Titi, 2018; Mikayilov et al., 2019). The lack of public transportation in Saudi Arabia is a reason for the increasing gasoline dependency and demand since people use their cars frequently (Al-Sahlawi, Miah, & Al-Titi, 2018; Mikayilov et al., 2019). In Saudi Arabia, ordinary consumers are the largest gasoline consumers (Al-Sahlawi et al., 2018). On average, 12 million vehicles are in use daily, and this is expected to increase up to 26 million vehicles by 2030 (M. Al-Sahlawi et al., 2018). Therefore, Saudi Arabia is the second-largest energy-consuming country in the Middle East and the eleventh-largest in the world, exceeding 3 million barrels a day (EIA, 2021a; Morrow, 2020).

Al-Sahlawi et al. (2018) studied the gasoline demand in Saudi Arabia. The study revealed six issues significantly affecting gasoline consumption in Saudi Arabia. These are:

- **Age:** the age group found to consume the most gasoline was 40–49-year-olds. This was due to their family and work responsibilities.
- **Nationality:** there are many nationalities living in Saudi Arabia. 10 out of 30 million are foreign residents. The study showed that Saudi nationals consumed 1.6 times more gasoline than foreign nationals.
- **Educational level:** PhD holders consumed the least gasoline, unlike the pre-high school and high school groups. People with a master's and bachelor's degree were equal in terms of their consumption of gasoline.
- **Employment characteristics:** the study shows that the unemployed and retired have the largest gasoline consumption compared to full- and part-time employees and students. This is explained by the fact that some businesses and schools offer their own transportation to their staff, a benefit not enjoyed by unemployed and retired people.
- **Monthly income**: the study shows that people with a higher income (SR 25,001 to SR 30,000) consume less gasoline than people with a monthly income of SR 15,001 to SR 20,000. The authors explain that this may be due to the fact that families with a higher income have more than one car, while people on a lower income usually own one car that serves the entire family.
- **Household size:** the size of a household has a significant impact on gasoline consumption in Saudi Arabia. Whenever the number of family member increase, their fuel consumption increase.

- **Vehicle engine size:** as the engine size rises, the gasoline consumption rises. There is a difference between four and eight cylinders. Eight cylinders usually consume more gasoline. The size of the engine in a car is related to family size and income.
- **Gasoline price:** whenever the price increases, gasoline consumption decreases. Al-Sahlawi et al. (2018) tested the market before an increase occurred in late 2015. Then, they compared the respondents' answers before and after the increase and confirmed the inverse relationship between gasoline price and consumption. 31% of the study's sample who were using the most gasoline were concerned about the price rising in the future.
- **Household location:** the study focused on eight regions in Saudi Arabia. Families in the Makkah region were consuming the most gasoline, those in the Eastern region were consuming the least, and the other regions were mostly the same.

In Saudi Arabia, gasoline is a subsidised product (Al-Sahlawi, 1997; Alyousef & Aljarrah, 2012). In 2012, the subsidy amount reached US$ 80 billion (Sarrakh, Renukappa, Suresh, & Mushatat, 2020). Due to the rapid increase in the cost of living in Saudi Arabia, the government implemented different policies and procedures that helped to alleviate rising costs while boosting the economy (AlDbian & Qassim, 2019; WAS, 2021). In 2021, the government set a cap on local gasoline prices: SAR 2.18 for the 91-octane grade and SAR 2.33 for the 95-octane grade (CNN, 2021; WAS, 2021). For any additional increases, the government will cover the difference. However, lowering the price is not a solution as it increases the local gasoline consumption, which in turn affects exporting capacity (Al-Sahlawi, 1997; Alyousef & Aljarrah, 2012). Away from supply and demand law, how do experts in Saudi Arabia look at gasoline from a supply chain point of view?

(3) Semiconductors Sub-case

Transistor technology was first introduced in 1947 at Bell Telephone Laboratories (Wessner, 2003). In 1955, Bell Labs shared its intellectual property on diffused-base transistor technology, allowing other researchers to access the knowledge and method. This was a major transition in transistor technology, resulting in the first integrated circuit in 1959. After then, the semiconductor industry grew rapidly until it became the largest value-added industry in the United States (Wessner, 2003). It became an engine for other growing industries and the future economy and became one of the national security's building blocks (SIA, 2022; Tadjdeh, 2021; Wessner, 2003). In 2001, worldwide semiconductor sales were US$ 139.0 billion, and they continued increasing, reaching US$ 555.9 billion in 2021 (SIA, 2022). The World Semiconductor Trade Statistics organisation is expecting that sales will increase in 2023 to US$ 633.0 billion (WSTS, 2022). Semiconductors are the largest electronic export and the fifth highest American product export with a total of US$ 62 billion, listed after refined oil (US$ 92 billion), aircraft (US$ 80 billion), crude oil (US$ 69 billion), and natural gas (US$ 68 billion) (SIA, 2022).

In 2003, the national research council in the United States of America published a book titled "Securing the Future". This was a regional and national programme to support the semiconductor industry. In a modern economy, semiconductors are regarded as having the same value as crude oil. They are a major component that increased different industries' productivity and facilitated their rapid development, such as telecommunications, automobiles, and military systems (Wessner, 2003). They are crucial to treating illnesses, education, travelling, entertainment, and many other fields (SIA, 2022). The White House listed semiconductors as one of the critical products that it needed to secure in its supply chain (Handwerker, 2022; Wessner, 2003). Handwerker (2022) mentioned three reasons that made them a critical product in the United

States: their lower capability, high global demand, and limited investment. In addition, it is considered to be one of the most complex industries, as it requires up to 26 weeks of lead time to produce a chip (Tadjdeh, 2021).

Due to the limited funds provided by the United States government before the pandemic of COVID-19, a shortage occurred. Other governments regarded this as an opportunity to fund and support this critical industry in order to secure their local markets (SIA, 2022). However, President Joe Biden signed the US$ 280 billion act (E.O. 14017) into law to build facilities and hire American experts in order to manufacture semiconductors inside the United States instead of relying on external suppliers, even its allies (Carberry, 2022; Tadjdeh, 2021). The United States was not the only one to invest in the semiconductor industry. China invested US$150 billion, with many other Asian countries and the European Commission subsidising this industry (Carberry, 2022).

Seven countries are dominating the global production of semiconductors market. The United States leads with nearly 47% of the global market share, while South Korea has 20%, Japan and Europe have 18% between them, Taiwan has 8%, and the global market has 7%, led by China (SIA, 2022). The three biggest companies dominating the semiconductor industry are Samsung in South Korea, Intel in the United States, and the Taiwan Semiconductor Manufacturing Co. in Taiwan (Tadjdeh, 2021).

The world realised the importance of semiconductors when the COVID-19 pandemic began (Carberry, 2022). During the pandemic, the demand for high-tech devices such as smartphones, laptops, and work-at-home devices increased due to the lockdown (Handwerker, 2022; KAUST, 2022). On the other hand, the demand decreased for other important sectors, such

as the defence department in the United States and the automobile industry (Handwerker, 2022; KAUST, 2022; Tadjdeh, 2021). Due to the criticality of semiconductors to the U. S. military, the Pentagon signed a contract with the Charles Stark Draper Laboratory to ensure the sustainability of a chip supply for its defence weapon system (Tadjdeh, 2021). Moreover, a three-year partnership with Intel, known as Structured Array Hardware for Automatically Realized Applications (SAHARA), expands access to domestic manufacturing (Tadjdeh, 2021). In 2021, the government of India announced their aim to become a major player in the global semiconductor market (American Ceramic Society Bulletin, 2022). Soon after, in March 2022, King Abdullah University for Science and Technology (KAUST), King Abdulaziz for Science and Technology (KACST), and the Research Development and Innovation Authority (RDI) organised the first forum on the future of the semiconductor in Saudi Arabia under the theme "Why now is the time to localize semiconductors?" (KAUST, 2022). It is the starting point for localisation, where experts and global and local investors gather to discuss the possibilities of localising the semiconductor industry (KAUST, 2022). Based on the purchasing portfolio model, what is the current status of the semiconductor industry in Saudi Arabia?

(4) Insulin Sub-case

An issue that is growing globally and increasing the mortality rate is diabetes (IDF Diabetes Atlas, 2021). The availability and accessibility of insulin are a global concern (ADIS, 2012; Kaplan & Beall, 2016). In 2021, the number of diabetic patients worldwide was 537 million, and this number is expected to increase to 783 million by 2045 (IDF Diabetes Atlas, 2021). In the Middle East and North Africa, 73 million were suffering from diabetes in 2021 (IDF Diabetes Atlas, 2021). Saudi Arabia has become the country with the second-highest rate of diabetes in the region, with

a total number of 4.6 million diabetic patients – this is expected to increase to 8.4 million by 2030 (HSTP, 2021).

As a treatment, diabetic patients use insulin; this is globally one of the products in the highest demand, and it is listed as an essential product in many countries (Kaplan & Beall, 2016). In the 1920s, insulin was discovered and extracted from animals (Beran, Lazo-Porras, Mba, & Mbanya, 2021; Kaplan & Beall, 2016; Tibaldi, 2014). Fifty years later, human insulin was introduced in 1977, and this progressed to basal insulin analogues in the 2000s (Tibaldi, 2014). It is the standard treatment that controls glucose levels in a diabetic person (Bishu et al., 2019). To reduce the number of diabetic patients, the government of Saudi Arabia has implemented different policies and procedures that aim to increase diabetic awareness, highlighting risks such as blindness, kidney failure, or, ultimately, death. It provides free access to public places where people can exercise and socialise – and in line with that, the government is working on ensuring the uninterrupted continuance of the insulin supply.

It is vital to understand the reasons behind drug shortages as part toward solving the issue. A recent study conducted to understand the reasons behind shortages of drugs in Saudi Arabia found seven factors contributing to this issue (Alruthia et al., 2018):

- The failure to notify the Saudi Food and Drug Authority (SFDA) in advance of an anticipated shortage.
- The weak management of the supply chain and logistic function, which resulted in either drug shortages or wastage.
- The ineffectiveness of applying penalties against licensed pharmacies that did not abide by SFDA regulations.

- The lengthy process of biological products being released by SFDA.
- The overdependence on external suppliers for critical medicine is due to the lack of local manufacturers, which only cover 20–25% of the local demand.
- The low-profit margin set by the SFDA for critical medicines must be increased in order to encourage investors.
- The procurement criteria need to be continuously updated.

Globally, 34 insulin manufacturers are recognised by the Health Action International Organisation (HAI, 2016). Three multinational companies dominate more than 95% of the global insulin market: Eli Lilly, Novo Nordisk, and Sanofi (Beran et al., 2019; HAI, 2016). One of the most important steps taken by the policy maker in Saudi Arabia was localising the insulin industry in Saudi Arabia to ensure the uninterrupted flow of the insulin supply and to satisfy the local and Middle Eastern and North African (MENA) markets. The first insulin factory called SaudiBio, was established in 2019. It signed an agreement to manufacture and supply insulin and haemophilia products in Saudi Arabia (Aldwaihi, 2022; Almousa & Alhmad, 2019; WAS, 2020). Its daily production capacity is half a million pharmaceutical units (Aldwaihi, 2022; CNN, 2022; WAS, 2020). It seeks to supply the MENA markets, which collectively have nearly 73 million diabetics (IDF Diabetes Atlas, 2021). In addition, in order to cover the lack of qualified personnel, the Saudi government has sent Saudi students to selected international educational institutes to enhance their capabilities, knowledge and skills in specific disciplines that support the promising sectors for the coming economic stages, with pharmaceuticals being one of them (Y. Abdullah, 2019). With all the policies and procedures that have been undertaken with the aim of securing the insulin supply, where do the experts position this product in the proposed classification matrix?

3.4 Research Approach

When using induction methods (theory-building research), the researcher's goal is to suggest theoretical concepts and patterns from observed data. On the other hand, when using deduction methods (theory-testing research), the researcher's goal is to use new empirical data to test concepts and patterns known from theory. Induction and deduction go "hand in hand in theory and model building" (Bhattacherjee, 2012, p. 15). Moving back and forth between induction and deduction results in an abduction approach, which is also known as retroduction (Rotaru et al., 2014; Saunders et al., 2019). It begins by observing the phenomena and then discovers a plausible theory of how this could have occurred (Saunders et al., 2019, p.155). Combining both approaches is considered best practice. In this case, the literature review defines the domain by providing the theoretical basis; then, the use of qualitative research moves the domain from an abstract stand to the identification of its manifest forms (Frey, 2018). Finally, the results of both the qualitative and quantitative approaches are drawn upon for the research recommendations and conclusion.

This research started with short observations on some of the critical intermediate and final products in Saudi Arabia that leads to holding a strategic reserve for on a national basis. It then moved on to theories, a literature review and interviews as an induction approach to answer the first qualitative research question: "What are the most significant variables that determine the level of importance of critical intermediate and final products at the national level in Saudi Arabia?" A deduction phase followed, where the model was tested quantitively, adding to the theory a new concept that has not been applied before in this domain.

3.5 Research Methodology

There are times when qualitative research is the most suitable method to apply, for example, when exploring a problem, honouring the voices of participants, or conveying multiple participants' perspectives. On the other hand, the quantitative method is suitable for understanding the relationships between various groups (Creswell & Clark, 2017). In other studies, mixed methods could be the best way of addressing the research problem. In mixed methods, the researcher combines elements of qualitative and quantitative methods, such as the use of qualitative and quantitative viewpoints, data collection, analysis and reasoning techniques. A mixed-method study is used for the broad purposes of width and depth of understanding and corroboration (R. B. Johnson & Onwuegbuzie, 2007). It could be applied in a wide variety of disciplines, including social, behaviour, and health science (Creswell & Clark, 2017). The use of mixed methods is justified when the researcher needs to first explore a topic before administrating an instrument; the researcher may not have identified the questions that need to be asked or the variables that need to be measured. This is the case with the study in hand due to the newness of the research topic and the environment being studied (Creswell & Clark, 2017). Regarding the selected research methods of this study, mixed methods were adopted as being best suited to answer the research questions.

In mixed methods, there are three standard core designs: convergent design, explanatory sequential design, and exploratory sequential design (Creswell & Clark, 2017). With the exploratory sequential design, the investigator begins with the qualitative phase, where they analyse the required data. Then, as a second phase, the outcome of the qualitative result is translated into an approach or tool that can be applied in the quantitative phase. In the final phase,

the investigator tests the new feature quantitatively (Creswell & Clark, 2017). Figure 19 presents the diagram of the exploratory design implemented in this research.

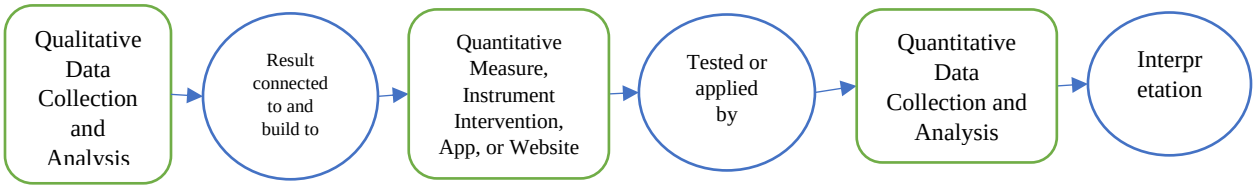

Figure 19: The Exploratory Sequential Design - Adopted from Creswell & Plano Clark (2022, cited by Creswell et al., 2017)

Exploratory research that seeks to identify measurement variables could be applied to measure the criticality level of intermediate and final products in a new environment, such as Saudi Arabia, where no similar studies have been conducted before, to the best of the author's knowledge. The qualitative method aims to answer the first research question, "What are the most significant variables that determine the level of importance of critical intermediate and final products at the national level in Saudi Arabia?". In contrast, the quantitative method aims to answer the remaining research questions (see section 3.1). With regard to the Literature Review, Figure 20 presents the Methodology Conceptual Framework.

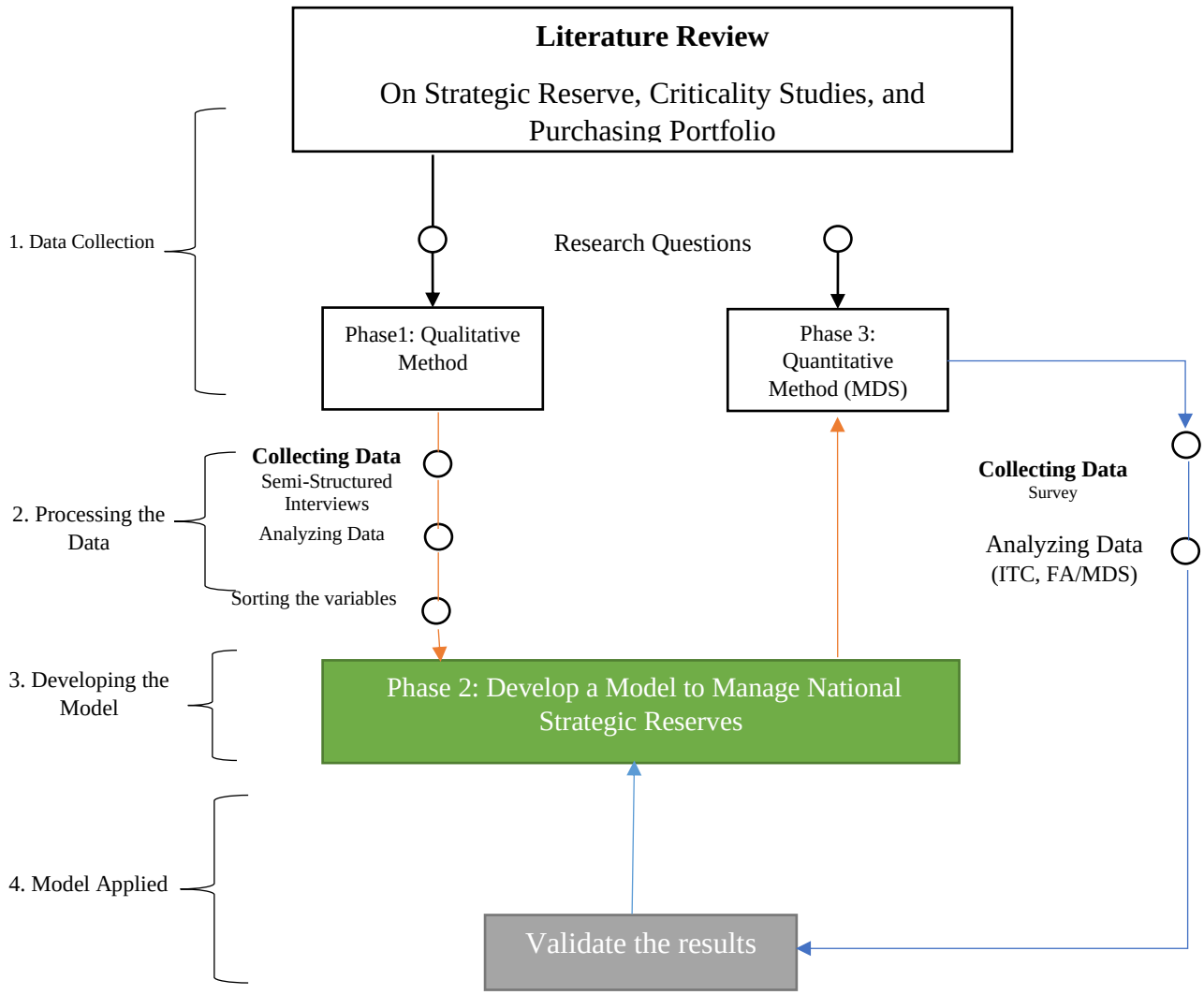

Figure 20: Methodology Conceptual Framework (2/2)

3.5.1 Qualitative Method

(1) Introduction

When studying a research problem that needs an in-depth understanding of its causal factors and its consequences, qualitative methods are recommended (Creswell & Clark, 2017; Creswell, 1998). Due to the limited number of studies published on the topic of managing the national strategic reserve and identifying the criticality level of intermediate and final products, particularly in the field of supply chain management, a qualitative method is an ideal methodology

to apply for exploratory research. It is a strategy that usually emphasises words rather than numbers when collecting the required data (Golafshani, 2015). Qualitative methods were employed first to verify, add, or remove the variables used in the research by answering the following question, "What are the most significant variables that determine the level of importance of critical intermediate and final products at the national level in Saudi Arabia?"

(2) Collecting the Qualitative Data

The qualitative research method was used to identify the study's variables, and semi-structured interviews were conducted with the participants using pre-formulated questions, as shown in Table 22 (Myers, 2009). A Delphi technique was employed for this research; this is an interaction technique between investigators and a group of experts, with the aim of obtaining the experts' opinions and judgements on a specified topic (Yousuf, 2007). It is used as an exploratory technique and involves interviewing experts in the field individually to explore a full range of opinions (Brown, 2018).

(3) Designing the Interview Questions

To ensure the creditability of the qualitative output, it is crucial to prepare for and design the interview. This qualitative research followed the framework of interview protocol refinement presented by Castillo-Montoya (2016: p.812), which consists of four phases. The first phase is ensuring that the interview questions align with the research questions, as there is a difference between the research and interview questions. The research questions seek to understand the phenomenon, while the interview questions seek to obtain that understanding from participants – this is the purpose of an in-depth interview. Therefore, interview questions must help the participants to tell their stories, and at the same time, they need to be aligned with the purpose of

the study (Castillo-Montoya, 2016). The second phase involved constructing an Inquiry-Based Conversation. At this phase, the researcher develops an interview protocol, which is considered an instrument of inquiry. Creswell and Clark (2017) define it as a tool that illustrates the purpose of the study, the terms of participating, and conversation questions about a particular topic. The purpose of the questions should be to understand someone's life, ideas and experiences.

Four main elements structure the interview protocol: the interview questions, which must be different from the research questions; the wording of the questions, which must be clear, understandable, and aligned with the social rules of ordinary conversation; having a variety of interview questions; and finally, having the protocol in a written form (Castillo-Montoya, 2016).

The third phase is receiving feedback on the interview protocol, which enhances the reliability and trustworthiness of the qualitative research instrument. For this research, the interview questions were reviewed by the study supervisors. In addition, two PhD students who were familiar with qualitative research and were conducting research on purchasing were asked to review the interview protocol before moving to the final phase, the piloting phase. They were provided with a close reading form adopted from Castillo-Montoya (2016) in order to share their feedback. This was extremely helpful in terms of improving and refining the interview protocol. In the final phase, the researcher simulated the actual interview in as real conditions as possible by piloting the interview protocol (Castillo-Montoya, 2016). A small volunteer group who met the criteria of this study's sample participated in the pilot study. Two academic experts, one industry expert, and two PhD students were invited to take part in the pilot study in order to assess and test the interview questions. They were asked to consider the clarity of the questions, the procedure, and the timeframe of the interview. Notes were taken and considered by the researcher during the pilot study. The final semi-structured questionnaire is detailed in the following section.

(4) Data Collection

To collect the required data for this exploratory research, three rounds of interviews were conducted, as mentioned earlier, using the Delphi technique. The first round was called brainstorming and focusing in preparation for the second round, and the validation round was the third. The brainstorming aimed to identify the most applicable measurements for measuring the criticality level of intermediate and final products in Saudi Arabia. After identifying potential experts, invitations were extended via text messages, email, and social media platforms like LinkedIn and Twitter. The interview time and location were then scheduled based on their responses. The interview followed the steps suggested by Castillo-Montoya (2016). First was an introduction phase where the researcher explained the aim of the research and the purpose of conducting the interview and asked the participant to sign the consent form. A transition question followed, linking the introductory questions with the key question of the second phase. Then, the main interview discussion, where the investigator presented the model without the variables and started the conversation by using the key questions, prompting the interviewees to express their own thoughts and ideas. Finally, the outro phase (closing questions), where the interviewees had an opportunity to discuss all the relevant points related to the model. At this phase, the interviewees are invited for the second round of interviews. The interviews were recorded using an appropriate recording device after the consent form had been signed. Figure 21 and Table 22 illustrate the interview protocol.

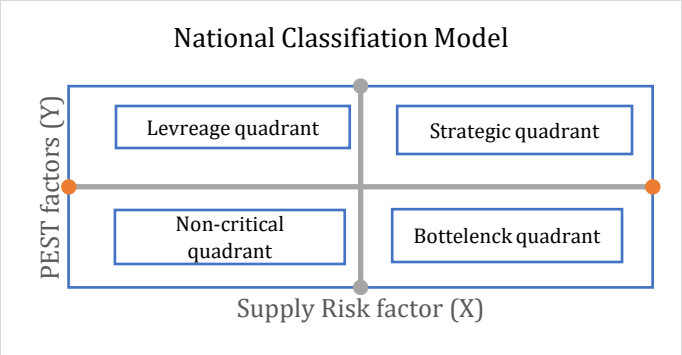

Figure 21: National Classification Model (NCM)

Table 22: Interview Protocol

Stage One: Brainstorming		
Introduction	Main questions	Outro
Illustrated the aim of the study, the purpose of conducting the interview, and the reason for nominating the interviewee. If they agreed to participate in the study, they were asked to read and sign the consent form before starting the interview.	Researcher presented the proposed model (Figure 22) to the participants and asked them to name and place a product into the matrix; then, the following questions were used for discussion: 1. How can we move this product from the strategic, bottleneck quadrants to the non-critical quadrant? 2. On the national level, how will a) politics, b) economics, c) sociocultural, and d) technology be impacted if there is a supply interruption or shortage of stock for one of these major products: grain, insulin, oxygen, petroleum, semiconductors, phosphate, COVID vaccine? in other words, what might occur if we run out of the product?	At this phase, the participants were asked: 1. If they had any comments related to the model. 2. They were thanked for their participation. 3. They were invited to the focusing round, which discussed only the extracted variables.

3. What (is/are) the factor(s) that limit or prevent the availability of this type of product in Saudi Arabia?
4. How can we ensure the continuity of supply flow without relying on external sourcing (foreign suppliers)?
5. From your experience, have you had any challenges or obstacles with either purchasing products from or supplying products to the local market?
6. How satisfied are you with consumer behaviour toward the strategic products in terms of obtaining the product, its usage and its disposal?
7. What must we do to maintain stock of these types of products?

Round two, the focusing round, took place when the brainstorming stage was finished (conducted, transcribed, and analysed). At this stage, the investigator returned to the key participants after the data had been analysed in order to collect their opinions about the results (the measurement variables) and whether or not they agreed with the outcomes. They were also asked if there were any additional matters that needed to be considered from their perspective (Creswell & Clark, 2017). It consisted of eight of the 23 participants in the brainstorming phase, as it shows in Table 23. They were invited individually to evaluate the extracted variables. First, the variables were shared with them, along with a brief statement about the research objectives. A week later, an individual meeting was conducted to discuss the variables in order to validate, rank and

prioritise them in terms of how they measured the criticality of intermediate and final products at the national level in Saudi Arabia. This was done for both the supply risk factors and PEST factors. Round 2 in Table 23 illustrates the participant's background in the focus stage. The final model's variables could then be determined. As a final stage of this study, the validation phase of the final result- products position, four of the 23 participants were involved, as illustrated in round 3 in Table 23. They were asked to express and justify their agreement on the final study results and the products' position.

(5) Study Sample

Expert sampling is "a technique whereby the researcher chooses the participants in a non-random manner based on their expertise on the phenomenon being studied" (Bhattacherjee, 2012: P.69). It is the appropriate approach for exploratory studies (Gelderman, 2003). As mentioned earlier, experts are used to verify and to add, remove or edit the variables of each dimension.

A total of 23 experts were involved in the brainstorming round. They all had theoretical and practical knowledge about the concept of national strategic reserves, and they dealt with at least one of the critical products, such as grain, oil, medicines, metals or semiconductors, in Saudi Arabia. They had to be a professional in the field with more than five years of experience. Semi-structured interviews were conducted individually with 12 experts in petroleum economics, water, agriculture economics, health economics, pharmacoeconomics, minerals, politics and purchasing, round 1 in Table 23 summarizes the participants' backgrounds. The interviews lasted between 1:00 and 1:30 hours at the participants' workplace. As in-person interviews were difficult to arrange, online interviews were conducted with the remaining 11 participants on Zoom, following Dublin City University's (DCU) guidelines (Data Protection Unit, 2020). The online interviews did not

exceed 30 minutes. After the twenty-three interviews, the decision was taken to stop, as the saturation level had been reached, and no additional data were collected.

Table 23: Participants' Background (Semi-structure interview)

#	P. Code	Participant Background	Round 1	Round 2	Round 3
1	SF03	Former government consultant, social science professor interested in national strategic reserve	√	√	√
2	MS01	Senior advisor to the Minister (leading ministry), professor of economics, dealt with the national strategic reserve	√	√	
3	MQ04	Professor of water and agriculture economics, former government consultant, farm owner	√	√	
4	AA02	Pharmacoeconomic professor interested in industry, logistics, and the economy, with great experience in the public and private sectors	√	√	
5	SS06	CEO of a leading company (billions of Saudi Riyals) that produces a critical product	√		
6	NK05	Former president of an organisation responsible for securing one of the national strategic products - PhD holder.	√	√	
7	SM08	Health economics professor	√		√
8	ZK07	Procurement supervisor in one of the top five leading companies in Saudi Arabia	√		
9	AM38	Computer science engineering professor	√		
10	KM33	Expert in technology interested in semiconductor industry	√		
11	AA39	Computer science engineering professor	√		
12	MK31	Medical logistics officer in a global organization	√		
13	SY48	Political and economist analyst interested in national strategic reserve	√		
14	SK36	Former government consultant interested in national strategic reserve	√		
15	ZA44	Chief procurement officer for leading company – PhD holder	√		
16	BB10	Former Vice President of the Research Centre at a well-known hospital in Saudi Arabia – Epidemiologist expert - PhD holder	√	√	
17	AS50	Responsible (coordinator) for securing one of the national strategic reserve products – Master holder	√		
18	NE51	Geological expert interested in strategic reserve, dealt with energy and minerals – Master holder	√		

Table 23 (continued)

19	AF56	Vice President of a reputable organisation in the Middle East. Managed multiple divisions related to fast-moving consumer goods (FMCG) sales and distribution, including food (cereals family) and beverage, personal and home care in modern and traditional trade channels in competitive markets	√		√
20	FA60	Food trader	√		
21	AM09	Well-educated historian interested in political, economic, and sociocultural issues	√		
22	OH15	Chief procurement officer in leading companies. Managed mega project in Saudi Arabia	√	√	
23	MM61	Computing and AI Professor	√	√	√

To gain an in-depth understanding of the research phenomena, the qualitative data were collected in Arabic as this was the participants' language for everyday communication in Saudi Arabia. It was also the first language of the main investigator. Using their daily language gave the participants the confidence to express, explain, and share their knowledge and experience, and this was reflected in the quality of the data collected. Indeed, it is a recommended strategy in cross-data collection when one of the researchers or more speak the same language as the participants and conduct the interview themselves (Uwe, 2018). One advantage of this strategy is that there is no need to employ additional members or third parties as the researcher can work alone; however, if the participants' language is not the researcher's first language or if the participants speak different languages, it is advisable to use different strategies such as a community researcher, professional interpreter/translator, or researcher and interpreter in tandem (Uwe, 2018).

(6) Data Analysis

To analyse the qualitative data, the thematic analysis technique was employed. This method is suitable for analysing the collected data with respect to the research objectives. Thematic analysis is an approach that seeks to understand people's opinions about the phenomenon being studied based on their experience and knowledge (Braun & Clarke, 2006). Thematic analysis

consists of six steps: familiarisation with the data, the generation of initial codes, the search for themes, revision of themes' definitions, naming of themes, and, finally, production of the report, as proposed by Braun and Clarke (2006).

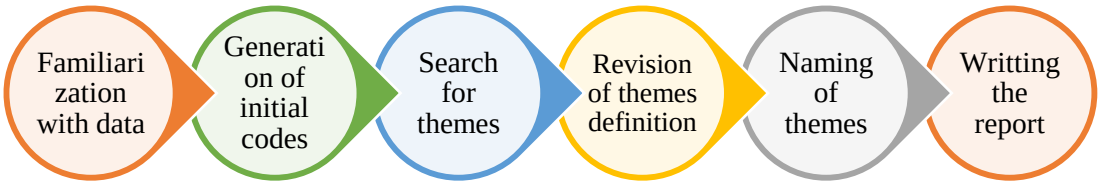

Figure 22: Thematic Analysis Steps

As described above, the interviews were conducted in the participants' preferred language, Arabic (van Nes, Abma, Jonsson, & Deeg, 2010), which made it easier for them to express their opinions (Chapman, 2006). The transcription process took place within 24 hours of conducting each interview. During the process of translating the data from Arabic to English for analysis purposes, a number of challenges could be experienced by either the researchers themselves or a professional translator, which affects the credibility of the qualitative results (Castillo-Montoya, 2016; Chapman, 2006; van Nes et al., 2010). Therefore, to avoid any potential mistakes in translating the meaning of the participant's opinions, the investigator used the original data for the analysis stage of the study, as suggested by van Nes et al. (2010): "We feel it can be stated that there is some influence when analysing in another language than your own. To avoid potential limitations in the analysis, we, therefore, recommend staying in the original language as long and as much as possible" (p. 315).

At this point, the data were ready for the analysis stage, which started with the researcher reading the whole data and building the first codes. In the second round, the investigator became more familiar with the data and codes, which made building the themes possible. The themes were related to the study factors, which are: political, economic, sociocultural, technological and supply risk factors. In the third round, the investigator was able to aggregate similar codes into one standing measurement variable.

In qualitative research, codes are most often a word or short phrase that symbolically represents a summative, salient, essence-capturing and/or evocative attribute for a portion of language-based or visual data (Saldaña, 2013: p.3). It is a fundamental element in processing and analysing qualitative data and making them meaningful in order to answer the research question (Elliott, 2018). In terms of including and excluding codes, all the data were coded except verbal fillers and body movements. Saldañ (2013) states that only the most salient portions of the corpus related to the research questions should be included. However, there are two forms of coding: prefigured and emergent (Elliott, 2018). The emergent form, which was implemented for this research, allows the raw data to speak for itself; this helps the researcher to explore more than they would have done with preformed codes. It gives the flexibility to the researcher to return back to the earlier codes and refine their analysis in the light of later code creation (Elliott, 2018). Then, as part of processing these codes, themes are created.

Themes are a combination of overlapping codes (Creswell & Poth, 2018). They are an extended-phrase or sentence that identifies what a unit of data is about and/or what it means (Saldaña, 2013: p.175). In terms of the number of themes, Saldaña (2013) suggested not exceeding five themes, and five emerged in this study: political, economic, sociocultural, technology, and supply risk factors. For example, GDP, interest rate, employment rate and others were coded

individually in the first round, and then they were combined to create the macroeconomic code under the economic theme. The following chapter discusses the findings of the qualitative research in detail.

(7) Qualitative Credibility (Validity and Reliability)

Testing the reliability and validity of the qualitative findings relies on the researcher's ability and effort in terms of collecting and analysing the data, as qualitative findings are based on non-statistical forms (Creswell & Clark, 2017; Creswell & Poth, 2018; Golafshani, 2015). In qualitative research, validity means method of assessing the accuracy of obtained information through qualitative data collection in terms of credible, transferable, dependable, and confirmable (Creswell & Clark, 2017). It reflects the trustworthiness, rigour, and quality of the qualitative paradigm (Golafshani, 2015). Creswell and Poth (2018) suggested nine validation strategies, and they encourage researchers to use at least two of them. These are prolonged engagement, triangulation, peer review, negative cases, clarifying researcher bias, member checking, collaborating with participants, generating (rich and thick) descriptions, and other peers or external audits. Three of these strategies have been employed to validate the qualitative research in this study: the use of external audits, member check and triangulation.

Two peers (graduate students) were invited to evaluate and examine the codes extracted by the main researcher (Creswell & Clark, 2017; Allen, 2017). Both were PhD students in the field of supply chain management, and they were familiar with qualitative research. Arabic is their first language, but they can also speak English. They were provided with the data and codebook that contained the themes, codes, and quotes in Arabic. Both of them were volunteers, and they had no connection to the study. A member's check it's a qualitative research method involve sharing the

participants the research finding in to validate the accuracy and interpretation of data (Creswell & Clark, 2017). It's part of the Delphi technique that was described by Yvonna and Egon (1981) as the most important validation technique in qualitative studies. At this point, the researcher provided the extracted variables from the literature and interviews and discussed them in detail with the interviewees, as illustrated in the data collection section, round two, the focusing round. Triangulation is the third validation strategy used to test the credibility of the qualitative result of this research. In triangulation, the researcher has a chance to apply different methods, sources, theories, and/or investigators to validate the qualitative result (Creswell & Poth, 2018). In this study, the process of triangulation was considered at multiple stages. As illustrated earlier, this research uses a mixed-method strategy to reach and validate its findings. It started with a qualitative research approach and ended with a quantitative finding. Before the final analysis step, the correlation of these variables was tested to identify statistically the validity of the most applicable variables, as discussed in the following section.

(8) Managing Bias in Qualitative Research

In qualitative research, bias might occur during the development of the questionnaire, when conducting the interviews, or analysing the data to produce the final report (Pannucci & Wilkins, 2010; Smith & Noble, 2014). Researchers can involve other opinions when developing the interview questions in order to avoid bias in qualitative research. A pilot study with experts in the field of business management was employed to shape the interview questions and ensure that they fitted the purpose of understanding the phenomena that the researcher was seeking to understand (Smith & Noble, 2014). While conducting the interviews, there was no personal interference or interpretations that could influence the participants' opinions or answers unless the participant asked for clarification. During data analysis, bias was managed through the use of two external

PhD students (Smith & Noble, 2014). They were asked to express their agreement or disagreement with the codes names and whether they represented what they had been used for. In terms of the language, the original data were analysed as they were in Arabic. The quotations that were used for the final report were translated by the primary investigator and checked by supervisors for accuracy. Finally, one of the advantages of mixed methods is the use of the triangulation technique, which minimises biases in research and enhances the credibility of the research outcome (Salkind, 2012).

3.5.2 Quantitative Method

(1) Introduction

The second phase of the exploratory sequential design in mixed-method research is the quantitative method. At this stage, the results of the qualitative research were translated into an instrument for quantitative research (Creswell & Clark, 2017). As illustrated earlier, the qualitative method consisted of conducting semi-structured interviews to verify the model's variables. Once these variables were confirmed, the quantitative method was employed in order to test the validity of the measurement variables in terms of determining the criticality level of products on a national basis. Stoudt (2014) defined quantitative as an exploration numeric pattern that uses a set of strategies, techniques, and assumptions to study social and economic activities. In this study, the quantitative approach was used to answer the following research questions:

- The literature review has revealed that there is a lack of studies determining the criticality level of intermediate and final products on a national basis. Based on the concept of a purchasing portfolio, on a national basis, how critical are rice, gasoline, semiconductors, and insulin in Saudi Arabia? This question is answered through the following sub-questions:

2.1 The Ministry of Environment Water and Agriculture in Saudi Arabia listed rice as one of the strategic products; how likely its true, based on the purchasing portfolio principles?

2.2 Based on the purchasing portfolio principle, is gasoline considered to be a strategic product in the country with the largest crude oil producer, Saudi Arabia?

2.3 The United States of America and China are competing on semiconductors products. Based on the purchasing portfolio principles, what is the criticality level of semiconductors in Saudi Arabia?

2.4 Insulin is a life saver for people with diabetes. Based on the purchasing portfolio viewpoint, what is the status of insulin in Saudi Arabia?

(2) Research Hypotheses

A research hypothesis is a clear, predictive, precise and testable statement about possible scientific research outcomes (Lavrakas, 2013). It states the relationship between two or more concepts and suggests that one has an impact on the other (Grix, 2004, p. 44). As this research examines the relationship between the independent factor supply risk and dependent PEST factors in terms of determining the criticality level of intermediate and final products at the national level, it employs the Pearson correlation coefficient to test the relationship hypotheses. Therefore, the null and alternative hypotheses of interest are:

H_0: *There is no relationship between supply risk and PEST factors in terms of determining the criticality level of intermediate and final products.*

H_1: *There is relationship between supply risk and PEST factors in terms of determining the criticality level of intermediate and final products.*

(3) Designing and Developing Study's Instrument

In social science research, Likert-type questionnaires are a common scale used to measure ordinal data. They include sample word statements to measure the extent of participants' agreement or disagreement. They tend to use a five or seven-point scale ranging from "strongly disagree" to "strongly agree" (Bhattacherjee, 2012). The Likert questionnaire deployed in this study contained seven sections, as discussed in the following section. It aimed to measure the criticality level of products on a national basis within a 10–15-minute timeframe. A scale from 1–7 was applied where 1 represents the negative answers, such as 'extremely scarce' or 'disagree', graduating to 7, which represents the positive answers, such as 'extremely available' or 'agree'. Table 24 represents the weighted mean of the scale.

Table 24: Weighted Mean

Weighted mean	Opinion/Attitude
From 1.00 to 1.85	(1)
From 1.86 to 2.71	(2)
From 2.72 to 3.57	(3)
From 3.58 to 4.43	(4)
From 4.44 to 5.29	(5)
From 5.30 to 6.15	(6)
From 6.16 to 7.00	(7)

The questionnaire was presented to the participants in their preferred language, either English or Arabic. It was accompanied by the cover letter, which described the purpose of the study and questionnaire in a very simple statement. It included a section on giving informed consent. It then took the participants to the section where they indicated the type of sector/product they are experts in the agricultural sector (rice), the energy sector (gasoline), the medical sector (insulin), and the telecommunications and technology sector (semiconductors).

The questionnaire contained a total of 44 questions, which were grouped into four sections. The demographic section contained four questions about the gender of the participants, the length of their work experience, their level of education, and the participants' background – whether it was theoretical, practical, or both. There were 37 multiple-choice questions in sections five and six about the variables confirmed from the qualitative research outcome. The fifth section aimed to evaluate the level of supply risk internally based on the national capabilities and resources. Then, it evaluated the external supply risk of the products. The sixth section evaluated the impacted PEST factors. It asks the experts to evaluate the impact of a shortage of the product at the national level. The seven and last section contained a word of thanks for the experts for taking part in this research.

I Pre-testing questions and content validity

As with the qualitative questionnaire, a pilot study was conducted to test and assess the quantitative survey. This enabled the researcher to assess how the instrument performed with a small group before conducting the actual study (Frey, 2018; In, 2017). Due to the nature of this research and the targeted sample, it was essential to conduct the pilot study for the quantitative research. Two rounds, consisting of a pilot study and external judgement for content validity, were used as a technique to test the feasibility of the instrument before moving toward the actual study (Frey, 2018).

Ten participants were involved in the first round of the pilot study. It consisted of six PhD holders, two master's holders, and two experts in the field of supply chain management. They were asked to consider the clarity of the questions and the procedure, and the process of answering the questions. After this, the researcher updated and modified the questionnaire based on the comments and feedback. Then, a second round of the pilot study was conducted, which involved

seventeen participants, including the previous ten. They were not included in the study's sample. Again, they were asked similar questions, clarity of the questions and the procedure and process of answering the questions.

As the final step of assessing the instrument, two academic professors in the field of supply chain management in Saudi Arabia voluntarily evaluated the questionnaire. They were asked to consider the clarity of the questions, the procedure and process of answering the questions, and the extent to which the instrument is meant to measure, and the language translation. After receiving their feedback, the instrument and researcher were ready to conduct the actual study, as discussed in the following section (see Appendix A). Figure 23 illustrates the final structure of the questionnaire.

(4) Administering the study's instrument

i Study Sample

In this qualitative research, an expert sampling technique was adopted to verify the model variables. However, in the quantitative research, the aim was to test the model by using the results from the qualitative research. To test the model's variables, four products were tested. In this regard, it is very important to ensure that the participants have the appropriate knowledge and experience to answer the questionnaire, as wrong answers affect the final results and, therefore, the positions of the products in the matrix. Thus, the focus was on professors in petroleum economics, agricultural economics, pharmacoeconomics, professors in technology, and traders and professionals at the executive level. They all had either theoretical, practical knowledge or both, and they dealt with one of tested products of this study, in Saudi Arabia. They had to be a professional in the field with more than five years of experience.

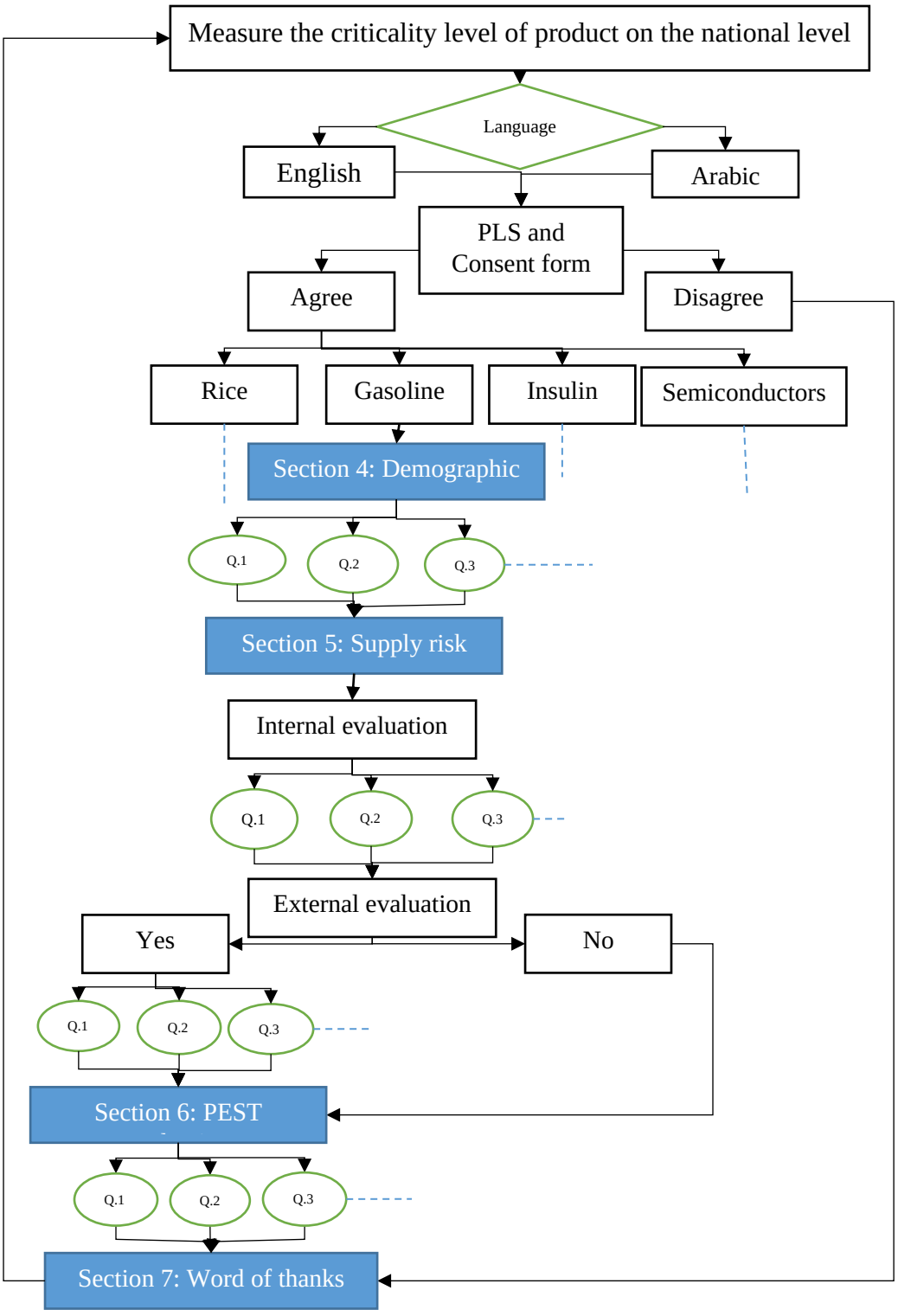

Figure 23: Questionnaire Structure

ii Data Collection

A total of 653 individual invitations were directed to the target participants either by email, text messages, social media, or by visiting them in their workplace. The questionnaire was distributed among faculty members in 13 Saudi universities: University of Jeddah (UJ), King Abdulaziz University (KAU), King Saud University (KSU), King Abdullah University of Science and Technology (KAUST), Umm Al-Qura University (UQU), King Fahad University of Petroleum and Minerals (KFUPM), King Faisal University (KFU), Qassim University (QU), Jouf University (JU), Jazan University (JaznU), Yanbu University College (RCYCI), and Jeddah, Riyadh, Jizan and Dammam College of Technology.

In addition to individuals in Saudi universities, experts in the following public sectors were invited: King Fahad Medical City (KFMC), the Ministry of Environment, Water and Agriculture (MEWA), and the Saudi Food and Drug Authority (SFDA). Finally, executive-level traders in relevant products were invited to take part in the study. During the six-month period of data collection, 152 experts who met the criteria for this research completed the questionnaire, as shown in Table 25. An online Google ® form was used as a platform to gather the required data by sharing a link with the target participants. This form can be accessed by clicking here.

Table 25: Participant Tracking Table

Attribute / Product	Rice	Gasoline	Insulin	Semiconductor	Total
Total invitations	126	69	222	193	653
Accepted the invitation	47	41	86	48	222
Rejected the invitation	0	0	2	7	9
No response	79	28	134	138	379
Total responses received	33	41	35	43	152

(5) Data Analysis

To analyze the quantitative data, testing the reliability of the instrument was the starting point. Then, the validity in two different techniques is used: the item-total correlations and factor analysis techniques. As the final step for determining the measurement variables before applying the multidimensional scale technique, the reliability of the confirmed variables was taken into consideration to ensure the instrument's quality outcomes. The following Figure 24 illustrates the steps for the quantitative data analysis.

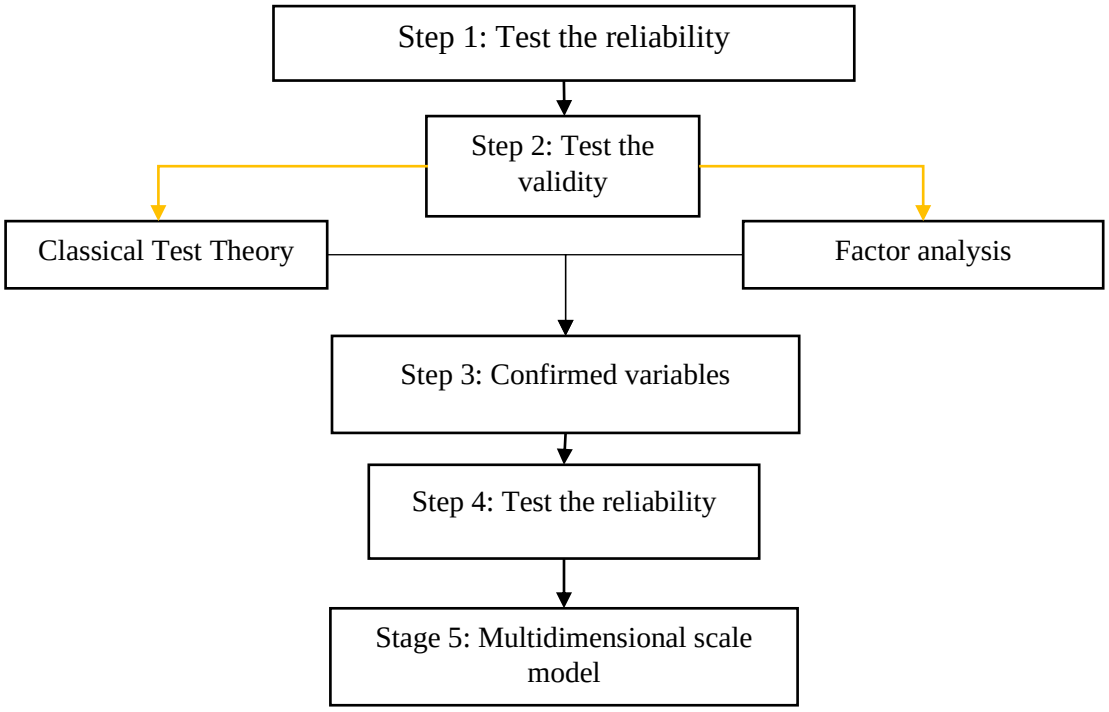

Figure 24: Quantitative Data Analysis Steps

i Test the Instrument Reliability

After conducting the required data from the actual study's sample, the reliability of an instrument was tested, which reflects the degree level of instrument accuracy. It means the possible extent of an instrument has the same results consistently if it is being used in the same situation on

repeated occasions (Heale & Twycross, 2015). The most common reliability test used is Cronbach's alpha which determines the internal consistency of an instrument in a result between 0 to 1 (Heale & Twycross, 2015). It can be applied to test the average of all correlations in every combination of spilt half or with a question that has more than two responses (Heale & Twycross, 2015). A score of 0.70 and higher is considered acceptable and reliable (Heale & Twycross, 2015). To ensure the reliability of an instrument meets the quality standard, the reliability of the instrument was tested first. The score of Cronbach's alphas was (0.830).

ii Test the Validity of the Instrument

In quantitative research, validity is defined as the extent to which the concept is accurately measured (Heale & Twycross, 2015). In order to test that, content validity was implemented, as mentioned earlier in section 3 of this chapter. It determines whether the content of an instrument adequately covers and measures what it is supposed to measure, and this is determined by asking field experts for their opinions (Boateng, Neilands, Frongillo, Melgar-Quiñonez, & Young, 2018).

To test the validity at this stage, two statistical methods were used: the item-total correlation and factor analysis (Tavakol & Wetzel, 2020; Frey, 2018). The item-total correlation, which falls under the Classical Test Theory, is a traditional test that aims to determine which functional items are correlated to each other. Frey (2018: p. 02) defined it as an approach to measurement that considers the relationship between the expected score (or "true" score) and the observed score on any given assessment. There are many techniques used for testing this relationship, such as item difficulty, item discrimination, inter-item and item-total correlation. It is commonly used for categorical items and distractor efficiency analysis for items with multiple-choice response options (Boateng et al., 2018). It is a technique used to support the deletion of

items with a score < 0.30 by examining the relationship between the item and the sum score of the rest of the items, excluding itself. It is preferred in a pool that can be calculated using SPSS (Boateng et al., 2018). Table 26 illustrates the correlation coefficient strength between variables.

Table 26: Rule of Thumb for Interpreting the Size of a Correlation Coefficient – Adapted from Hinkle, D.E., Wiersma, W. and Jurs, S.G. (2003) as cited by (Mukaka, 2012)

Size of Correlation	Interpretation
0.90 to 1.00 (−0.90 to −1.00)	Very high positive (negative) correlation
0.70 to 0.89 (−0.70 to −0.89)	High positive (negative) correlation
0.50 to 0.79 (−0.50 to −0.79)	Moderate positive (negative) correlation
0.30 to 0.49 (−0.30 to −0.49)	Low positive (negative) correlation
0.00 to 0.29 (0.00 to −0.29)	Negligible correlation

In addition to the Classical Test Theory, the factor analysis technique was used. This is a statistical technique used to validate the internal structure of an instrument and to determine the potential variables that should be measured or excluded (Tavakol & Wetzel, 2020). It is considered an important step during the development and validation of an instrument as it determines the optimal number of factors prior to using them in other analysis techniques, such as multiple regression and multivariate analysis (Shrestha, 2021).

As stated by Shrestha (2021), there are three major steps involved in factor analysis: the suitability of data assessment, factor extraction, and factor rotation and interpretation. To assess the suitability of data, there are two main factorability assessments – Kaiser Meyer Olkin (KMO) and Bartlett's Test of Sphericity. KMO tests the adequacy of the sample size, giving a value from 0 to 1. The closer the value is to 1, the better the data is for factor analysis. Table 27 summarises

the indication value of KMO. On the other hand, Bartlett's Test of Sphericity should be under 0.05 to be significant (Shrestha, 2021).

Table 27: KMO Values (Shrestha, 2021)

KMO Value	Indicator
0.80 to 1	Adequate
0.70 to 0.79	Middling
0.60 to 0.69	Mediocre
0.50 to 0.59	Acceptable for sample sizes less than 100
Less than 0.49	Factor analysis might not be suitable

The second step is extracting the model variables, which is achieved by employing principal component analysis. In this research, the Kaiser's (eigenvalue) Criterion and the Scree test were applied as the exploratory stage of factor analysis. The eigenvalue explains the total amount of variance by factor (Shrestha, 2021). If the eigenvalue is greater than 1, the factor is significant, and this indicates that more common variance than unique variance is explained by that factor (Shrestha, 2021). In addition, the Scree test indicates with a graphical visualization the optimum number of factors that can be extracted in two dimensions. The x-axis represents the component number, and the y-axis the eigenvalue. The extruded factors should be stopped at the point where there is an "elbow" or levelling of the plot (Shrestha, 2021). However, as stated by Boateng et al. (2018) and Tavakol and Wetzel (2020), when the slope coefficient of the variable is 0.30 and above, this is considered adequate, while < 0.30 is considered inadequate since this means that they contribute less than 10% of the latent construct measured.

To confirm the final measurement variables, the factor rotation test was applied. There are two main methods for factor rotation. The orthogonal method assumes that factors are uncorrelated, and it employs varimax, quartmax and equimax. On the other hand, the oblique method assumes that the factors are correlated, and it utilises either the promax or the direct oblimin method. In this research, the varimax method of orthogonal factor rotation is used. It tends

to minimise the number of variables that have a high loading on each factor that is presented in the rotated component matrix (Shrestha, 2021). If the rotated component matrix results in more than one significant component, it is recommended that the analysis is rerun, reducing the loading items across the rotated component matrix (Shrestha, 2021). For this research, the varimax analysis resulted in nine significant components, which were reduced to two components aligning with the study's supply risk factors and PEST factors. With this method, it is essential that the researcher exercises some judgement when determining the relevant factors (Shrestha, 2021).

A recode variable technique was applied to measure the criticality level of the final selected measurement variables, where higher risk = higher value (Berenson, Levine, & Szabat, 2015). As mentioned earlier, a scale from 1 to 7 was used. For the participants, 1 represents the negative side that indicates the scarcity and dissatisfaction levels. On the other hand, the positive side, 7, indicates a high level of availability and satisfaction. In some variables, such as the level of availability of qualified personnel, if it is leaning towards the scarcity level (1), it indicates a high level of risk, while 7 means that the availability ratio is extremely high; therefore, there is no risk from the variable being measured. Table 28 illustrates the recoded variables.

Table 28: Recoded Variables

S. No.	Recoded Variables	Variable code
1	Availability of required raw materials and natural resources	NCMX01
2	Availability of feasible alternatives	NCMX02
	Availability of local producer	NCMX05 (A)
3	Availability of investors	NCMX06
4	Self-sufficiency	NCMX04
5	Availability of scientific research centers	NCMX08
6	Satisfaction of overall logistic services	NCMX14
7	Satisfaction of the accuracy of available data	NCMX16
8	Satisfaction of the consumption behavior	NCMX21 (A)

Table 28 (continued)

9	Availability of policies and procedures to manage the consumption behavior	NCMX21 (B)
10	Satisfaction with the implementation of policies and procedures to manage the consumption behavior	NCMX21 (C)
11	Availability of global supplier	NCMX05 (B)
12	Export capacity	NCMX27
13	Trade Agreement	NCMX29
14	Availability of qualified personnel	NCMX03

To conclude the validation phase of the quantitative research, it's recommended to test the reliability of the instrument after determining the measurement variables (Boateng et al., 2018). Again, the reliability is assessed by the use of Cronbach's alpha. The score at this stage improved from 0.830 to 0.843.

iii Applied the Multidimensional Scaling Model

After ensuring the reliability and validity of the instrument and their variables applicability, the mean of each variable for each product was counted. It considers a transition stage in this research as the outcome is used as an input to the last analysis technique, the multidimensional scale model. In positioning products into the matrix, this study followed the lead of Arantes, Alhais, & Ferreira (2022), Ferreira, Arantes, & Kharlamov (2015), D. M. Lee & Drake (2010), Padhi et al. (2012) in positioning the products in the portfolio matrix. The data were uploaded into IBM SPSS software version 28, and a Multidimensional Scaling (MDS) model was used to position the products in the national classification matrix. This is a statistical technique founded in 1939 by Eckart and Young. It has become a common measure of the similarity or dissimilarity of an object being studied in many different disciplines, such as marketing, political science, sport and others (Hout, Papesh, & Goldinger, 2013; Saeed, Nam, Ul Haq, & Bhatti, 2018a). It aims to visualise the given data in an understandable graphical display by fitting a set of points in a space,

where the distance between these points corresponds as closely as possible (Hout et al., 2013; Mazzocchi, 2011; Saeed et al., 2018a; Wilkinson, 2002). The key element of this technique is the object being studied, which might be a product, brand, or behaviour (Mazzocchi, 2011). To employ a multidimensional scaling model, the analyst needs to (Buja et al., 2008; Hout et al., 2013; Mazzocchi, 2011):

1. **Lunch with an appropriate data,** which in this study was based on a set of variables extracted from qualitative research. As mentioned earlier, a 7-point Likert scale was used to measure the criticality of the products at the national level. It is one of the most popular tools used when applying MDS techniques (Mazzocchi, 2011; Saeed, Nam, Ul Haq, & Bhatti, 2018b).
2. **Select the appropriate scaling method,** which in this study was metric scaling (Hout et al., 2013). Therefore, with metric scaling, it is recommended to exploit factor analysis to reduce the dimensions then use the scores as coordinates (Mazzocchi, 2011).
3. **Determine the number of dimensions** it uses the Scree plot to determine the number of dimensions. "Elbow" is the most common method to look at in determining the number of dimensions. It is the value in which adding additional dimensions will no longer improve the goodness-of-fit (Hout et al., 2013; Wilkinson, 2002). Increasing the number of dimensions adds a greater degree of freedom to the movement of individual points, which increases the information represented by the solution and decreases the Standardized Residuals Sum of Squares (STRESS) of the solution (Hout et al., 2013). Therefore, it is important to find a balance between findings and STRESS. When using MDS, it is not

recommended to go beyond three dimensions (Hout et al., 2013; Saeed et al., 2018a; Wilkinson, 2002). Based on that, two dimensions were set for this research for the following reasons:

a. The use of Scree Plot "elbow" as it shows in Figure 25.

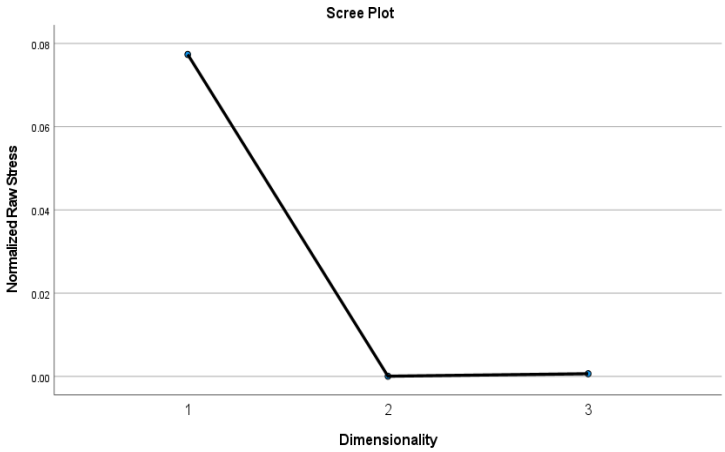

Figure 25: Scree Plot

b. The use of (STRESS), which is the statistical goodness-of-fit. In MDS, it is used to indicate the goodness of fit within the value between zero to one, whereas the closes to zero indicate a better fit (Wilkinson, 2002) which has been met by this study, as it can be seen in the Tables 29.

Table 29: Goodness-of-fit

Stress and Fit Measures

Dimensionality: 1

Normalized Raw Stress	.07737
Stress-I	.27815[e]
Stress-II	.64848[e]
S-Stress	.11008[f]
Dispersion Accounted For (D.A.F.)	.92263
Tucker's Coefficient of Congruence	.96054

PROXSCAL minimizes Normalized Raw Stress.

e. Optimal scaling factor = 1.084.
f. Optimal scaling factor = .938.

c. Based on the supportive theory of this research, Resource Dependency Theory, there are two factors: the casual independent factor supply risk and the impacted dependent PEST factors.

d. The purchasing portfolio sets the basis for this research, which consists of two dimensions rustling four quadrants that met the study requirements; therefore, adding a third dimension means nine quadrants (3x3), which upsets the core principles of the purchasing portfolio (Gelderman, 2022).

4. Run MDS analysis.

3.6 Research Ethics

To align with the research ethics at DCU, the first requirement for this study was to obtain the Research Ethical Committee's (REC) approval (Ref. No.: DCUREC/2021/054) to collect the data for this study (see Appendix B). The REC aims to ensure the following (REC, 2015):

i. That the rights and welfare of human participants and animal subjects in research studies or trials are protected.

ii. Research that is ethically sound and legally compliant with national and EU legislation.

iii. Informed consent is gathered, and before interviews are conducted, all the participants are informed of the process and the purpose of the study.

iv. All participants are informed that all the information they provide willingly will be anonymised and kept confidential.

v. All participants are informed that their participation in the study is completely voluntary and that he/she is entitled to withdraw from the study at any time during the research process. Each participant's consent is obtained in advance.

To ensure anonymity, each participant will be allocated an individual code when the researcher is typing up the interview. The data will only be available to the researchers, and all such data will be stored in a secure and private manner at DCU, Ireland.

Chapter 4: Qualitative Results (Understanding the Model Dimensions)

4.1 Introduction

To identify the measurement variables that measure the criticality level of intermediate and final products on a national level, an exploratory sequential design of mixed-method research was employed to answer the research questions. It starts with qualitative research, which aims to determine the measurement variables, followed by the quantitative research presented in chapter five. This chapter seeks to answer and understand the following research question, what are the most significant variables that determine the level of importance of critical intermediate and final products at the national level in Saudi Arabia?

One of the important elements of this research is the study's scope, which is the assessment of the risk of supply at a national level. It seeks to identify the most applicable measurement variables as there is a difference between national and organisational levels in terms of interest and approach to assessing the criticality of products. As the study reveals, there is a relationship between the concept of the criticality level of products on the national level and the five study factors (themes): politics, economics, sociocultural, technology, and supply risk. Each of these themes consists of a number of variables (codes) that were translated into an instrument for the quantitative part of this research. In presenting the qualitative research findings, it starts with the independent factor, the supply risk, then ends with the impacted dependent factors, PEST.

4.1.1 Supply Risk Factor

Twenty measurement variables were employed to measure the supply risk factors. These variables combine the typical and sustainable supply chain risks (Giannakis & Papadopoulos, 2016). The typical supply chain risks include disruption and delays caused by various factors, such

as issues with the availability of raw materials, qualified personnel, suppliers, investors, and the vulnerability of supply. There are also supplier issues, which include matters such as dependency on external suppliers, the capacity limit of suppliers to supply the required products; the complexity of the product, which is related to the product design; logistics issues such as transportation, warehouses, infrastructure, etc.; and demand issues, such as the accuracy of forecasting, managing demand, and global competition for the required product (Chopra & Sodhi, 2004). In addition, the results include risks related to sustainability, which are represented by the behaviour of consumers with regard to purchasing intermediate and final products, the stability of the country, and the operational costs (Giannakis & Papadopoulos, 2016). In this research, these variables were categorized under three sub-themes: availability, capability, and supplier properties, as summarized in Figure 26.

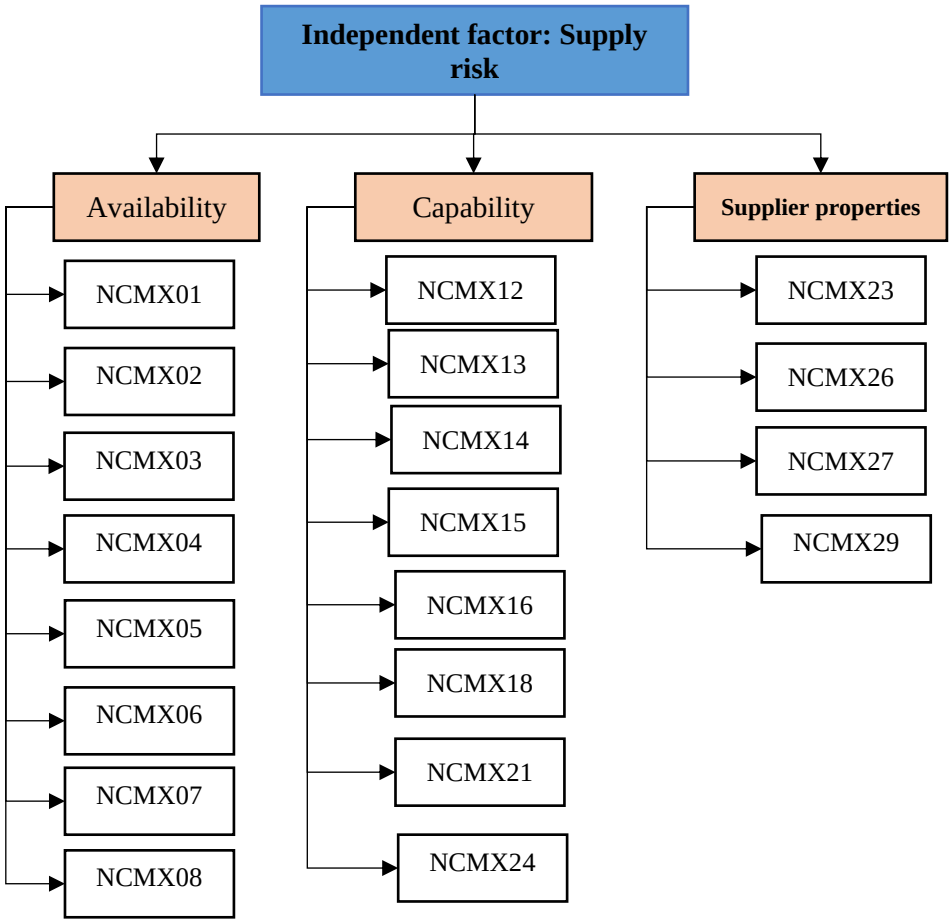

Figure 26: Independent Factors (Qualitative Data)

Sub-theme (1): Availability

1. **NCMX01: The availability of required raw materials and natural resources:**

In order to produce any type of intermediate or final product, it is important that the required raw materials and natural resources are available. This determines whether or not the product can be produced locally. One of the challenges to insulin manufacturing in Saudi Arabia is the availability of the required raw materials, "*... although we just started localising the insulin industry here in Riyadh, still one of the obstacles we have here is the availability of raw materials, it depends heavily on raw materials, which are totally supplied from outside the kingdom ... it's a challenge, a big challenge*" (AA02). To farm locally in Saudi Arabia, the availability of the most important neutral element, water, is a big challenge. Most of the

participants mentioned that. For example, MQ04 said, "*here in Saudi Arabia, water is an extremely strategic product … we don't have any natural sources unlike Ireland, if you dig less than one metre you might find water, whereas in Saudi Arabia you are talking about more than three hundred meters … so in your model, water in Saudi Arabia definitely comes here (participant pointed at strategic quadrant), while in Ireland if they have a shortage that means they have a problem with supplying the water, which is here (participant pointed at bottleneck quadrant).*" On the other hand, SS06 talked about cement and how the availability of the required raw materials makes it easy and profitable to produce over there: "*take for example cement. In my opinion, it is a highly demanded product, profitable for investors, requires simple technology, and all the other required components, or let me say raw materials, are available here in Saudi Arabia*." In terms of the literature, the variable has been considered to measure the supply risk factor in scopes organisational level such as (Ferreira et al., 2015; Kraljic, 1983). However, on the national level, it is used as an object to measure whether if the available or not known as critical raw materials (Achzet & Helbig, 2013; Arendt et al., 2020; Galos et al., 2021; Glöser et al., 2015; Graedel, 2011; Gupta, 2008; Helbig et al., 2016; Mancini et al., 2013; Nassar et al., 2015).

2. **NCMX02: The availability of feasible alternatives:**

   As long as there is an alternative to the product, the criticality of this particular product becomes less. The variable was considered at different scope levels as a supply risk measurement variable, see for example (Achzet & Helbig, 2013; Arendt et al., 2020; Ferreira et al., 2015; Galos et al., 2021; C. J. Gelderman & Weele, 2002; C. Gelderman & mac Donald, 2008; Glöser et al., 2015; Graedel, 2011; Gupta, 2008; Helbig et al., 2016; Hudnurkar et al., 2016; Kraljic, 1983; Magalhães et al., 2017; Mancini et al., 2013; Nassar et al., 2015; Weele,

2010; Zeh et al., 2020). During the interview with NK05, who was talking about the availability of perfect substitutes for products in Saudi Arabia, he said, "*Running out of wheat is not an issue that could harm the society … as long as you have other alternatives, which we already have … not only rice, but dates could also be an alternative … our antecedents used to live on it… so you will be fine….*" MQ04 agreed with NK05, as he mentioned, "*… I don't believe we will be having issues … we already have other alternatives to satisfy our needs … well, it might not be the perfect substitute as I understand the importance of grains to our culture, but you won't have a famine, do you see what I mean? There is always something else.*" There is also the electric car, which is considered an alternative solution to the petrol car. While MS01 was speaking about the use of gasoline and how other alternatives reduce the demand for this type of crude oil product, he said: "*…transportation sector is the largest … 60% consumed by the transportation sector and the remaining 40% … they are trying to reduce it by implementing other energy options … In the UK, you will find a charger at every parking meter. I was in London two weeks ago, a lot of things have changed … Electric cars become more efficient, and cost less, approaching gasoline cars and sometimes less. The electric battery is amazing, made from lithium keeps car running for more than 300 miles with the same charge … China will export more than nine to ten million cars in a year, which will be increased in a form of geometric fit… it's a big improvement*." MM61 provided an example of a perfect substitute in the automobile sector, Tesla: "*… other alternatives start to appear like Tesla in the automobile industry … solar has become or let me say is now considered the perfect energy substitute*."

3. **NCMX03: The availability of qualified personnel:**

On a national level, it is crucial to determine whether or not there are people who can produce a product. Due to its criticality, the variable of availability has been used as a supply risk

measurement by many scholars at different levels, such as the national and organisational levels (Arendt et al., 2020; Chou & Chang, 2008; C. Gelderman & MacDonald, 2008; Glöser et al., 2015; Graedel et al., 2012, 2015; Hudnurkar et al., 2016; Isik & Vayvay, 2018; Weele, 2010; Zsidisin et al., 2004). In addition, this was mentioned during the interview by AA02, SM08, and KM33. AA02 looked at it from the national security standpoint, "*Currently, most of the pharmaceutical industry in Saudi Arabia are foreigners, not Saudis, this has a security sense, Aiman … all medical factories are run by non-citizens … for any reason at any time they might leave, what will you do then?"* However, as part of solving this issue and ensuring the availability of qualified people, SM08 mentioned the Saudi's government initiative of providing scholarships in different disciplines to fill the local labour market gap: "*Now… we started seeing the output of the scholarship programme … many scholars return back with high knowledge and experience that makes them able to do it*."

4. **NCMX04: Self-sufficiency:**

This refers to the extent to which the nation can sustain itself without relying on others (Rutherford, 2002). It aims to measure the availability ratio of domestic reserves to consumption and the ratio of local production. In the case of a shortage or if the local supply does not meet the required demand, it is necessary to hold a strategic reserve for the required critical product in order to achieve self-sufficiency. As SF02 said: "*… the strategic reserve has become essential for many countries suffering from the shortage of the basic needs, like here in Saudi Arabia … our government is more concerned about achieving self-sufficiency for most critical products … look for example at the grain and petroleum strategic reserves we hold*." The concept was also applied on the organisational level under the name of safety stock, which is used to measure the supply risk factor; see, for example, Achzet and Helbig (2013), Arendt

et al. (2020), Chou and Chang (2008), Galos et al. (2021), Gelderman and MacDonald (2008), Glöser et al. (2015), Graedel (2011), Gupta (2008), Hatayama and Tahara (2015), Helbig et al. (2016), Hudnurkar et al. (2016), Isik and Vayvay (2018), Mancini et al. (2013), Nassar et al. (2015), Weele, 2010; Zsidisin et al., (2004).

5. **NCMX05: Availability ratio of (local/global) suppliers:**

One of the core variables that is considered at all levels is the availability of suppliers, whether local or global. If the suppliers of required products are available, there will not be a risk in product supply, unlike the scarcity of suppliers. However, what makes a product more critical is if there are a limited number of available sources all over the world. For this reason, the availability of suppliers was one of the variables found in the literature to measure the level of supply risk, such as Beran et al. (2019), Christopher and Peck (2004), Erdmann and Graedel (2011), Ferreira et al. (2015), Geng and Ji (2014), Hudnurkar et al. (2016), Kraljic (1983), Magalhães et al. (2017), Weele (2010), and Zsidisin et al. (2004). Additional to the literature review, semiconductors were mentioned by AM38 during the interview: *"Now that features are approaching the single nanometer sizes, only a handful of companies worldwide can produce these devices*." Then he said: "*It is not comparable to other industries, and thus, only a few foundries are involved in this business. The raw material is not the main issue, though always there is a need for new materials. The main issue is the necessary semiconductor-manufacturing equipment and maintaining them. The equipment is produced by a few companies based in Japan, Europe, and the United States.*" Although the United States is leading the semiconductor industry, due to the shortage of semiconductors, "*... the US president announced that they are attempting to open other manufacturers other than Intel to assure the flow of supply for this type of product*." (KM33). In Saudi Arabia, as part of the

solution for this issue, the government tends to encourage Saudi investors – in particular those who deal with products in high demand – to diversify their investment locations with government support. "*You know, in Saudi Arabia, we have agreements with other countries like Brazil and India … for example, our investors here own many lands and farms in Brazil, India, Ethiopia, and other countries … in fact, in so many countries … so if there is any supply issue in Brazil we have alternative sources and so on"* (SF03). Speaking about the status of insulin in Saudi Arabia, BB10 looked at it from the cost point of view. He preferred outsourcing instead of localising the industry: "*… Currently, only three insulin manufacturers produce 100% of insulin in the US market (the top insulin manufacturers are Eli Lilly, Novo Nordisk, and Sanofi) and more than 90% of the global insulin. Few countries can manufacture insulin, namely, the USA, Canada, Denmark, France, Germany, Italy, Ireland, Russia, Japan, China, and Brazil. Hence, as there is more than one foreign supplier of insulin, outsourcing insulin is cost-effective*."

6. **NCMX06: Availability ratio of investors:**

One of the key elements is the availability of investors who can serve society under the supervision of the government, either for a certain period of time or with other incentives. One of the examples mentioned by SF03 was government agreements with other countries. However, not all types of industries are favoured by investors. For instance, AA02 said: "*We don't have the capital or investor who would like to wait to have a return on an investment after 50 or 60 years … why should I hold more than 100 million on something and get it back after these years while there are some other opportunities for me, and it might be more profitable?*" Therefore, AF56 suggested diversifying government funding to include sectors other than agriculture and health: "*as a government promotes agribusiness finance and*

investment, it promotes agroecology and biodiversity like hydroponics on a large industrial scale." In terms of the literature review, this variable has been studied on the national level Achzet and Helbig (2013).

7. **NCMX07: External dependence:**

   The variable aims to measure the level of reliance on external suppliers, i.e., the import ratio. In terms of measuring the supply risk factor, the increase of reliance on external suppliers increases the possibility of supply risk. "*... we are still in the early stage of producing insulin… we still import a large amount from outside*" (AA02). This was how he viewed the insulin status in Saudi Arabia, whereas SS06 used the medical devices industry in Saudi Arabia as an example of how we rely on external suppliers: "*... you know that we are importing 98% of our major medical devices since we don't have local manufacturer ... what are you seeing is just packaging or maybe a distributor*." The variable has been considered in many national studies such as Achzet and Helbig (2013), Arendt et al. (2020), Glöser et al. (2015), Gupta (2008), and Helbig et al. (2016).

8. **NCMX08: The availability of scientific research centres:**

   This variable has a major role in reducing the criticality level of intermediate and final products; therefore, it has been considered as a supply risk measurement variable in many studies on a national level, such as Arendt et al. (2020), Erdmann and Graedel (2011), Graedel et al. (2012), and Helbig et al. (2016). During the interviews for this research, SM08 suggested scientific research centres as a way of solving the supply risk issue for major medicine in Saudi Arabia. She said, "… *not only this, Aiman, but you also need scientific research centres before... then you think about factory to start the process*." MM61 made the same suggestion: "… y*ou need to focus on developing a technology facility, I mean inside your country ... stop*

importing technology … do more research centres to ensure having an agreement with leading manufacturers."

Sub-theme (2): Capability

9. **NCMX12: Supply vulnerability:**

Speaking about the national strategic reserves and the reasons for holding a reserve for critical products is a consequence of the vulnerability of the supply flow for required products. This variable aims to measure a product's vulnerability to disruption through any of the following circumstances: adverse weather, natural disaster, climate change, war, global pandemic, or cyberattack. Having regards to the literature review, the following are examples of studies that used supply vulnerability as a variable to measure the supply risk factor at the organizational and national level studies Achzet and Helbig (2013), Beran et al. (2019), Christopher and Peck (2004), Gelderman and MacDonald (2008), Gupta (2008), Hudnurkar et al. (2016), Kilian (2008), Liao et al. (2016), Melnyk et al. (2021), Zhang et al. (2017), Zsidisin et al. (2004). During the interview, the variable was repeated many times by different participants; for instance, MS01 commented: "*When Al-Houthi attacked our refinery … although it was a very short period of time, two weeks only, approximately 50% of our production capacity per day of crude oil, completely stopped … the question here that most people are concerned about right now is what will happen if we have a war that attacked more than two oil fields at one time. Will we be able to return back quickly or not? This question is still being asked up to this day … Some arguments said it's an imported product from unsecured sources, which is not true in my opinion.*" SF03 looked at it from a political point of view: "*Political prudence is to have a strategic reserve for the most important and major things, to be prepared for any unexpected issues, especially in the case of wars or emergencies*." This was confirmed by

ZA44: "*we are located in an unstable region, look around you… Yemen, Syria, Lebanon, Sudan, Iraq, Iran … even though we are safe so far and the government is doing all the efforts to ensure the safety of our nation, still they could interrupt any imported product or export.*"

10. **NCMX13: Supplier's country stability:**

One of the elements most considered while outsourcing required products or raw materials at all levels is the stability of the government regime in the supplier's country. If there is a concentration of a product that is in high demand in an unstable country, that will threaten the flow of supply. Therefore, on a national level, this variable has been used to measure the supply risk level. See, for example, Anser et al. (2020), Arendt et al. (2020), Galos et al. (2021), Glöser et al. (2015), Guo et al. (2020), Gupta (2008), Isik and Vayvay (2018), Liao et al. (2016), Mancini et al. (2013), Nassar et al. (2015), Zhang et al. (2017). While being interviewed, SF03 kept repeating that "*The better the executive authority, the better the rest of government agencies' performances are.*" MS01 provided an example when he compared Iran with other governments in terms of using one of the national resources, crude oil. He said: "*Look at Iran and how they are selling their valuable sources, do you know, although Iran is under economic sanctions, still they are exporting a very limited volume by the black market … why? They offer a great discount to market their products as it's not accepted internationally to deal with Iran"*.

11. **NCMX14: Logistic challenges:**

Nation's capabilities are varied. Some countries are able to support a high standard of infrastructure, such as many ports and airports with good facilities, different warehouses and transportation methods, while others hardly have a silo to reserve grain in. Therefore, it is important while evaluating the supply risk on a national level to assess the logistic services

that the nation is characterised by. This variable aims to measure the level of overall internal logistic facilities related to the product being tested in Saudi Arabia, such as ports, roads, warehouses, communication, distribution, storage risk, etc. The variable has been considered as a supply risk measurement in different studies (Beran et al., 2019; Bianchini et al., 2019; Gelderman & Weele, 2002; Gelderman & MacDonald, 2008; Isik & Vayvay, 2018; Kraljic, 1983). Looking at the study participants' points of view, SS06 was not satisfied with the performance of some of the government departments, compared with the funding they have in terms of logistic services *"They do have a problem with distribution … Supply chain is your brain, your muscles … we use a brain for planning, forecasting, measuring the demand … and the muscles to act by delivering, storing etc. We are just using our muscles, sorry to say that … we still have a big problem with the logistics.*"

12. **NCMX15: Policy and procedures intervention:**

In some cases, for a certain type of product, governments tend to impose a policy to manage the availability of the product based on the local needs and interests. In intermediate and final products, we have seen the government of Indonesia, which banned palm oil in order to give priority to local consumers (Indriyadi, 2022), and the government of Egypt when they banned the export of rice to Saudi Arabia due to local needs (Mohy, El Aasar, & Sakr, 2023). Therefore, it is crucial to measure the extent of the intervention ratio of government policy and procedures in a supplier's country and whether it is (with or against) the (use or supply) of the product or raw materials externally. The variable has been employed to measure the supply risk factor on the national and organisational levels. See, for example, Chou and Chang (2008), Ferreira et al. (2015), Gelderman and Weele (2002), Gelderman and MacDonald (2008), Glöser et al. (2015), Hudnurkar et al. (2016), Nassar et al. (2015), Roelich et al. (2014), and

Weele (2010). That was confirmed by NK05, who had previously managed a strategic product in Saudi Arabia. He said: "*You remember back in 2008 or 9 when Egypt banned exporting rice to Saudi Arabia, it was not because of a diplomatic issue or something like that … they were looking to satisfy their local needs. How are you going to export something while you need it locally?"* Indeed, while I was writing this report, two different cases occurred. India stopped exporting rice, but they excluded Saudi Arabia from the ban, which might be because of the agreement between these two countries. Following that, Indonesia banned exporting palm oil as they were giving priority to the local market and industries.

13. **NCMX16: Forecasting accuracy ratio:**

In today's economy, it is crucial to predict the future demand for and supply of a product. On an organisational level, companies usually hold what is called a safety stock inventory in order to meet unexpected demand – on the national level, this is a called strategic reserve. If there are repeated forecasting errors, this can limit a company's profit. However, on the national level, it might affect one of the PEST factors, if not all of them. Therefore, it is important to predict the future demand for products, for example, by looking at population growth. By identifying the future demand, the flow of supply can be managed, which reflects positively on the level of supply risk. Achzet and Helbig (2013), Hatayama and Tahara (2015), Helbig et al. (2016), and Mancini et al. (2013) are examples of studies that have used this variable to measure the supply risk factor. During the interviews, MS01 highlighted the issue of unexpected seasonal demand in Saudi Arabia, "*we had a problem before with the seasonal demand during Hajj, there was a high demand for diesel*." OH15 understood that it was essential to have accurate forecasting of demand "*to plan the inbound stock level, the forecasted consumption accuracy is a must.*"

14. **NCMX18: Complexity ratio:**

Some products are very sophisticated; therefore, they are not easy to produce, or they might require a specific condition or environment for their manufacture, like insulin in Saudi Arabia. AA02 commented: *"You are talking about a sophisticated and very complicated industry; it requires special manufacturing conditions and investment… in 2016 or 18, I forget, we opened a new insulin factory for this reason, to meet the local demand … frankly speaking they are suffering*." For this type of industry, BB10 agreed with AA02, as he said: "*they need a sequencing machine to build human protein and synthesise DNA and large tanks to grow bacteria*." In addition, SS06 mentioned: "*I just finished a meeting related to manufacturing (participant preferred not to mention the product) here in Saudi Arabia, instead of importing them. Still, we are studying the project, it's a big challenge, to be honest with you.*" AM38 shared the same point of view about producing semiconductors in Saudi Arabia: "*The main issue is the necessary semiconductor-manufacturing equipment and maintaining it … it is very difficult to establish*."

To the best of the researcher's knowledge, this variable has so far only been included in studies with a national scope (Achzet & Helbig, 2013; Blengini et al., 2017; Mancini et al., 2013).

15. **NCMX24: Operational cost:**

One of the consequences that increase the risk of supply for critical intermediate and final products is their high operational cost, such as the oil product. MS01 said: "*As for oil… its costs are very high, there is no doubt about it. The insurance itself is very pricy, especially with the political affairs.*" The variable was conserved in many studies to measure supply risk on the national and organizational level, such as Achzet & Helbig (2013), Arendt et al. (2020),

Dabhilkar et al. (2016), Erdmann & Graedel (2011), Ferreira et al. (2015), Gangurde & Chavan (2016), and Garzon et al. (2019).

16. **NCMX21: Consumer behaviour:**

Since the focus of this research is critical intermediate and final products, it is appropriate to measure consumer behaviour towards products. How they buy them, consume them, and dispose of them. Solomon (2018, P.28) define consumer behaviour as "*the study of the processes involved when individuals or groups select, purchase, use, or dispose of products, services, ideas, or experiences to satisfy needs and desires"*. One of the examples of consumer behaviour was mentioned by MS01 when he was talking about how people consume gasoline in Saudi Arabia. He said: "*Since it's a subsidised product, we don't appreciate the real value of this resource, you just use your car even for a short distance … this is a waste of resources … now with the new policies and changes in the price, people start to think before they go anywhere … is it worth or not to use my car?*"

In this study, to measure this variable, the question directed to the experts was divided into three parts: how satisfied are you with: a) users' consumption behaviour in terms of usage and disposal methods; b) the availability of policies and procedures to manage the consumption behaviour of consumers (e.g., increase the price, impose fines, educate society about optimal use of products, etc.); and the level of implementation of these policies and procedures? In terms of recyclable products, they were asked to express their level of satisfaction level with the available policies and procedures on recycling products, as well as their implementation. Most previous criticality studies have only considered the recycling ratio on a national basis (Achzet & Helbig, 2013; Ben Hassen et al., 2020; Galos et al., 2021; Hatayama & Tahara, 2015; Helbig et al., 2016; Schneider et al., 2013).

Sub-them (3): Supplier properties

17. **NCMX23: Global market competition:**

With critical products, in a case of a few suppliers, an increased demand increases the level of supply risk. On a company level, that could be represented by the market share – the higher the market share, the higher the profit. However, on a national level, it has different implications. Du and Graedel (2011) used the global market competition to measure the level of supply risk where higher global competition for the product increases its criticality level. The product assessed was raw materials. In his interview, MS01 described the current global competition for petroleum products: "*To this date, the whole world still relies on petroleum products although there are alternatives, and I believe the demand will remain to the end of this decade, after that the oil will lose its value.*"

18. **NCMX26: Market conditions and structure:**

Understanding the market conditions and structure is one of the most important elements when evaluating product suppliers on a national basis – is it a monopoly, or a small group of people controlling the market, for example, cartels (Geng & Ji, 2014; Graedel & Erdmann, 2012; Mancini et al., 2013)? On the organisational level, market conditions have been considered when measuring the supply risk (Gelderman & Weele, 2002; Gelderman & MacDonald, 2008; Weele, 2010; Zhang et al., 2017). One of the things that surprised me while interviewing MK31 was that he said, "*Corruption may also be a player in the matter when certain parties get benefit from importing some medicines, which we have seen, unfortunately.*" It might be worse when the source of the product is unknown, "*you might get it from black market, sometimes you don't know the source of it, or it's not preserved within the required conditions"* (MK31).

19. **NCMX27: Export capacity:**

If the required product is not available locally, it is essential to identify the capacity limit of external product suppliers. This variable has been used in many studies to measure the supply risk factor, such as in Beran et al. (2019), Blengini et al. (2017), Gelderman & MacDonald (2008), Geng and Ji (2014), Guo et al. (2020), Liao et al. (2016), and Mancini et al. (2013). In some conditions, suppliers are unable to satisfy demand due to their limited facilities or the global demand for the product. As an example, when KM33 talked about the possibility of manufacturing semiconductors in Saudi Arabia, he said, "*... we have made it here lately, as the minster Al-Sowaha mentioned in his last speech, but I'm not really sure if we could supply other countries or not, still there are some points not clear for me*."

20. **NCMX29: Trade agreements:**

When there is flexibility between buyer and supplier, the level of supply risk decreases. On an organisational level, where profit is the ultimate goal, that might be manageable in a mutual agreement between both parties; however, on a national basis, usually there is government (diplomatic) intervention in the form of a trade agreement. As FA60 suggested, to ensure the flow of the product supply, the government should "*try in-country farming, do more research on farming technology developments, ensure that you expand or have better-storing facilities, focus on value-added facility developments, ensure you have long-term foreign trade agreements on raw materials*." One of the practical examples, as mentioned earlier, is the government-level agreement between Saudi Arabia and India, Brazil, and many other countries, "*we have an agreement with other countries like Brazil and India, for example, our investors here own several lands and farms in Brazil, India, Ethiopia*" SF03. Examples of studies that have applied this variable as a supply risk measurement are Arendt et al. (2020), Blengini et al. (2017), Erdmann and Graedel (2011), and Hudnurkar et al. (2016).

4.1.2 PEST Factors

This section presents the factors that were extracted from the qualitative data. It deals with the political theme, economic theme, sociocultural theme, and technology theme. Under each of these themes, a number of codes were created to represent the themes, as discussed in detail below. The political and technological themes consist of one code, whereas the economic theme contains six codes, and there are two codes to measure the sociocultural theme, as summarized in Figure 27.

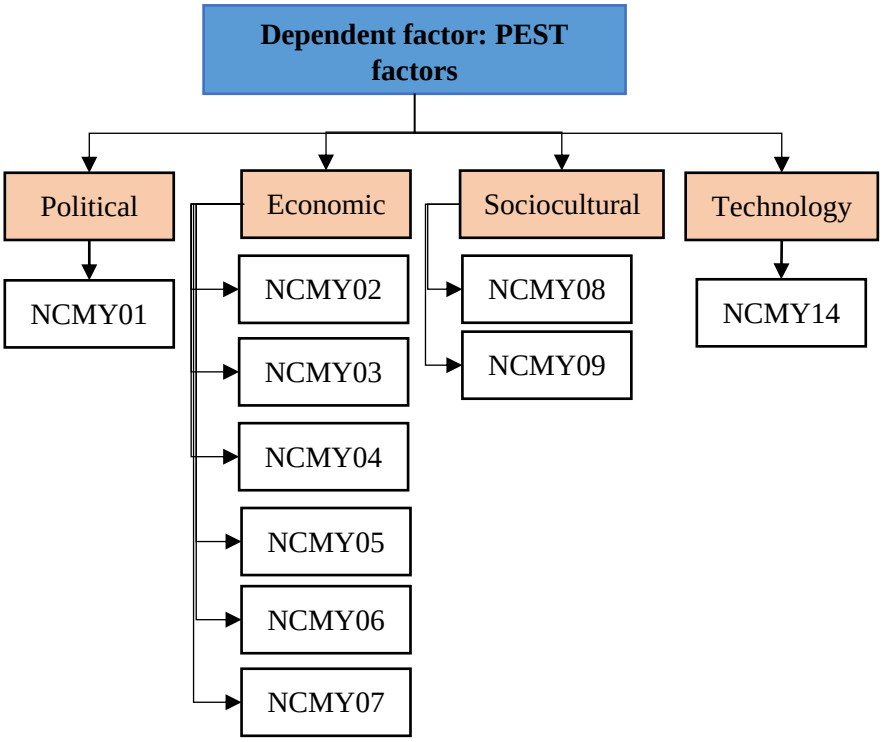

Figure 27: Dependent Factors (Qualitative Data)

Political (P) theme

1. **NCMY01: National stability and security:**

   A number of variables (codes) were extracted from the interviews related to the political factor, such as government reputation, stability, performance, productivity, and national security. All

of these variables (codes) were merged to form the national stability and security variable. Most studies have considered this variable under the supply risk factor to measure the level of risk that might occur when sourcing products; see Achzet and Helbig (2013), Breisinger et al. (2014), Liao et al. (2016), and PHAST (2017). However, since this study is focusing on national stability by holding a national strategic reserve for required products, it considers this variable as a dependent variable that might be affected by the independent variables (supply risk factor). During the interviews, most of the participants mentioned the political sense during critical product shortages. For example, SF03 said, "*government does all these administration duties to make our life much better and safer. Always when you would like to understand other cultures or societies, you look at the political system first… it gives you an indication of which level this society is in … the knowledge and the power of these people. So, … the better regime, the better life you will have … if not, people will suffer a lot."* SY48 referred to the Arab revolution and to the lack of basic needs, which led to a change in the regime of many Arab countries, "*there is no doubt that failing to provide the basic needs for your people will increase their dissatisfaction with their government. This may break down the security, which increases the level of instability; perhaps it might lead to demands to change the system, like the Arab revolutions in Egypt and Algeria before… I believe you are aware of what happened during that time … it was not safe.*" NE51 mentioned that *"riots and tension erupted during the era of President Anwar Sadat in 1977. It was about to become a revolution because the bread price increased due to the shortage in supply."*

Economic (E) theme

2. **NCMY02: National macroeconomics:**

"*It concerns national income, total consumption, investment and the money supply"* (Rutherford, 2002: p.361). Holding a national strategic reserve for the required product has a positive impact on many of the economic factors such as employment rate, interest rate, GDP, etc. When NE51 spoke about the consequences of shortage, he mentioned that "*stopping the factories led to layoffs of their employees, which resulted in an increase in the number of unemployed*." In addition, SS06 said, "*You need an industry that creates a job for your people, you are a big country, almost 30 million, not like our brothers and families in the United Arab Emirates or Kuwait … the total population does not exceed 5 million. Therefore, I'm telling you to keep what you have ... change it, modify it, but don't destroy them …these are people's jobs …the reality is more accurate than academia in some cases, right?*" (SS06). To the best of my knowledge, this variable has only been applied in national scope studies, such as Achzet and Helbig (2013), Anser et al. (2020), ESCWA (2020), Geng and Ji (2014), Gupta (2008), Liao et al. (2016), PHAST (2017), Schrijvers et al. (2020), Warner (2010), and Zhang et al. (2017).

3. **NCMY03: Price stability:**

   One of the reasons behind the holding of national strategic reserves is a desire to maintain the product price, as mentioned earlier in section 2.3. During the interviews, one of the most mentioned variables was the price of the product. MS01 talked about the beginning of the national strategic reserves concept when there was a diplomatic issue between Saudi Arabia and the US. He said, "*The world was worried … If you remember, the first thing that happened when the disruption occurred was that the price of oil jumped up to more than $70 … since then, the concept of strategic reserves began.*" SY48 referred to the law of supply and demand, "*of course, once we run out of any type of product, the first thing that will be affected is the*

price … definitely it will increase, it is a supply and demand law." ZK07 pointed out that "*price means supply and demand.*" In the studies reviewed in the literature review, the variable was applied in different levels see (Anser et al., 2020; Beran et al., 2019; Biswa, 2020; Chou & Chang, 2008; Garzon et al., 2019; Geng & Ji, 2014; Gupta, 2008; Hudnurkar et al., 2016; Irfanto et al., 2019; Liao et al., 2016; X. Liu & Xu, 2008; Zhang et al., 2017).

4. **NCMY04: Demand:**

   An increase in demand means that the product is critical for its consumers. As long as supply meets and satisfies the required demand, the market is considered stable. However, if, for any reason, an interruption occurs, that will be reflected in the criticality level of the product. A shortage of some products like insulin might lead to disaster, especially in a case of high demand, while the lack of some other products that are in high demand might not harm society. In this regard, AA02 mentioned, "*We do not have self-sufficiency of almost 20% of the essential medicines … this is the problem, self-sufficiency … the demand is high, the local manufacturer does not cover the existing demand, so you have to source from outside.*" On the other hand, when MQ04 was talking about the grain in Saudi Arabia and how people consume it, he said "*we use it daily, especially here in the kingdom. This is the most important product, we a lot as we use it in our breakfast, lunch, dinner. You can do different types of food using grain, unlike other products*." Different studies have considered this variable as a dependent variable when measuring the criticality level of the object being tested (Arendt et al., 2020; Graedel & Erdmann, 2012; Hudnurkar et al., 2016; Kraljic, 1983; Schrijvers et al., 2020; Weele, 2010).

5. **NCMY05: Criticality of the product:**

   One of the reasons why the government was concerned about holding strategic reserves for certain types of products is the criticality of these product for the national interest. For instance,

in Saudi Arabia, "*oil is considered a dominant product in Saudi Arabia… this is your front line, the whole world uses it*" (MS01). Later during the interview, he also said, "*In the nineties, the world was relying on petroleum significantly. Each economic growth unit needs one and a half of oil to grow economically one unit. So yes, it was very significant. The importance of oil now not like before, most countries are now trying to separate their economic growth from oil, so they can grow without the need to have oil.*" SK36 gave an example of semiconductors and how that affected the automobile industry all over the world, "*I'm not an expert in this field, but I have heard in the news lately that there is a shortage of semiconductors, which affects the car industry mainly*." On a similar theme, NE51 commented: "*the interruption of cotton may stop the production of cotton clothes, but the interruption of fuel leads to great damage to the industry sector and factories … it may stop the production of all consumer goods or reduce production … it might interrupt or stop transportation and communications … it might completely stop the country*." In addition to qualitative results, the variable has been used at the organisational and national levels. See, for example, Achzet and Helbig (2013), Anser et al. (2020), Biswa (2020), Du and Graedel (2011), ESCWA (2020), Geng and Ji (2014), Hudnurkar et al. (2016), Kraljic (1983), Law and Krishna (2020), and PHAST (2017).

6. **NCMY06: Investment:**

Some products are considered to be critical inputs for public projects or services. If there is a delay in the supply of these products, the consequences of this shortage might affect the expected return on investment. On the organisational level, this is understandable, as return on investment is the ultimate goal in most cases. Therefore, it has been considered in many studies as a dependent variable (Ellram & Olsen, 1997; Kraljic, 1983; Liu & Xu, 2008). Confirming the validity of this variable, SM08 mentioned during the interview that "*it might take more*

than 50 years to start getting a return on your profit ... from their point of view, is not worth it ... Why should I hold my money for 50 years, and usually you are talking about billions, while I have some other opportunities with an immediate return?" MK31 believed that "*the small profit margin, especially in the case of some products with low consumption, is not encouraging the investors, the difficulty of securing the required raw materials….*"

7. **NCMY07: Government expenses "Overfunding":**

Overfunding is defined as "*the issue of more government bills and bonds than is necessary to finance government expenditure*" (Rutherford, 2002: p.433). A shortage of some products might increase the national debt in order to satisfy the local market needs. When AM09 was talking about shortages and to what extent they might affect the nation, he said, "*What will happen here? The government might either get a loan and let the country suffer 100 years ahead or print more money without having a cover for that, which makes the issue worse.*" This might lead to subsidies of some products, as is the case with wheat in Saudi Arabia, *"You know this is one of the products that is subsidised by the government. The price for one kilo is five SAR, but what you pay is 0.5 SAR, yah half a riyal only ... rice, for instance, is not subsidised*" (MQ04). In addition, as mentioned earlier, SM08 talked about the cost that might occur due to the absence of insulin or other critical medicines. She said, "*really costly ... this is how we classify the diseases ... by knowing how much it costs the government ... We have different types of costs, not only the cost of treatment but the spread of the disease has a very big role. The more it spreads, the more costly and stressful it is to eradicate it."* Looking at the literature review, many studies have mentioned this variable as a shortage consequences that the public sector might have during the absence of critical products. See, for example, ESCWA (2020), Kiley (2019), Liao et al. (2016), Panagiotou (2013), and PHAST (2017).

Sociocultural (S) theme

8. **NCMY08: Criticality of the product's survival:**

What is the purpose of a strategic reserve if it is not to survive? A strategic reserve refers to products that are essential for our human life; without them, someone might lose his/her life. This study does not consider luxury products such as beauty treatments or video games. The variable has been applied in national-level studies. See, for example, Breisinger et al. (2014), Dirks et al. (1980), ESCWA (2020), Glöser et al. (2015), Kiley (2019), Pfeffer and Salancik (1978), PHAST (2017), and WHO (2020). During the interview, SF03 detailed the difference between critical and luxury products. He said, "*When I look at my needs, I find thousands of things, but what do I really need in order to live and exercise the minimum in my normal life? This what matter*."

9. **NCMY09: Society's attitude:**

The lack of some critical products might affect attitudes in terms of purchasing habits, crimes, abusing the law, or un-behaviour attitudes. It depends on the product and the duration of the product's absence. Some studies have linked the effects of product shortages with society's attitude, such as Achzet and Helbig (2013), Arendt et al. (2020), ESCWA (2020), and Glöser et al. (2015). These studies were carried out on a national basis as they were concerned about the stability of society. When a question was directed to the participants about what might happen if there was a shortage of an essential product, I received so many answers. One of them was from AF56, who said, "*In instances of scarcity of key resources, individuals would be fighting with each other to secure these basic essentials for survival. When survival is at stake, human beings cannot be expected to abide 'strictly by the book'. The very fabric of social unity would be at risk, and it would be a society whose only intent would be survival and*

nothing beyond that. The sociocultural interaction will be the main casualty, and it would be 'every woman/man for herself/himself' sort of a scenario." MQ04 talked about the example of steel during the shortage back in the 1990s in Saudi Arabia, "… *ten years ago the price of steel reached 4000 SAR for one ton …unfortunately, some people stole the sewer covers and sold them … it was really a big issue at that time and so risky, even the outside box of our air conditioning ….*"

Technology (T) theme

10. NCMY14: Advancement of national technology and innovation:

Technology plays a major role in Saudi's economy and community. One of the government's aims is to be one of the most advanced countries in science, technology, and innovation by launching a program called the National Science, Technology, and Innovation Plan (NSTIP). The aim of the program is to determine which technology is strategic for future development in Saudi Arabia (Alsodais, 2013). That was in line with MM61, who said, *"… although that we are still in our early stages in terms of technology … but look what we have done with the use of technology, most of the government services became digital, Absher, Enjaz ….*" However, one of the major components to ensure the sustainability of technology is the semiconductor which considers *"…the brain of technology*", as it was described by KM33. Looking at the literature, one of the main reasons for carrying out the criticality studies was to ensure the future of technology by determining the required raw materials that are scarce. See, for example, Chapman (2011), Glöser et al. (2015), Graedel (2011), Graedel & Erdmann (2012), Gulley et al. (2018), Hatayama & Tahara (2015), Jin et al. (2016), Mancini et al. (2013); Nassar et al. (2015); Panagiotou (2013), Peck et al. (2015), Roelich et al. (2014), Sivek et al. (2019).

4.2 Conclusion

At this point, the qualitative research is concluded. Five factors (themes) were explored affecting the criticality level of intermediate and final products on a national basis. These are politics, economics, sociocultural, technology, and supply risk. Each of these themes consists of a number of variables (20 variables for supply risk factor and ten variables for PEST factors). These variables were translated into an instrument for this research's quantitative part, discussed in the coming chapter.

Chapter 5: Quantitative Results (Product Categorization)

5.1 Introduction

The quantitative phase of this study was built on the qualitative results. It aimed to statistically validate the model's variables and to determine the critical level of rice, gasoline, semiconductors and insulin on a national level. The chapter starts by discussing the demographic part of the questionnaire. The chapter then moves on to describe the collected data in the form of the experts' opinions on the variables for each product. This is followed by a section on the instrument's reliability and validity. It then presents the products' position in the proposed matrix using the multidimensional scale technique that has been discussed with experts as validation phase of this study.

5.1.1 Demographic Part of the Research

The research questionnaire began with demographic questions that served as a fundamental guide to the different categories that the participants belonged to. The first question determined whether the participants' preferred language was English or Arabic; as the study was conducted in Saudi Arabia, where Arabic is the main language, it was vital to give the participants the option of the two languages (Uwe, 2018). The following questions, after the plain language statement, were about the type of sector the participants worked in, their gender, level of education, the length of their experience, and their type of experience (theoretical and/or practical).

One hundred and fifty-two experts were involved in this research, and they were divided into four different sectors. Thirty-three (22%) experts in the field of agriculture examined rice; 41 (27%) experts in the field of energy evaluated gasoline; 43 (28%) experts assessed semiconductors; and 35 (23%) in the pharmaceutical field evaluated insulin. As seen in Table 24, 73% of the experts

used Arabic rather than English to answer the questionnaire. The majority of experts (34%) held a doctoral degree, 34% held a master's degree, and 32% had a bachelor's degree. Most of the participants (89%) were male, and the remaining 11% were female. More than one hundred experts (67%) had worked in their field for over ten years, 22% had been in their current field for five to less than seven years, and 11% had been in their field for seven to ten years. Just over one-third (35%) of the experts had a theoretical background, 27% had a practical background, and the remaining 38% had both a theoretical and practical background in the products being evaluated. Table 30 summarizes the result of the demographic questions.

Table 30: Demographic Data Result

Variable	**Group**	**Sectors/ Products**				
		Agricultural sector (Rice)	Energy sector (Gasoline)	Telecommunications and technology sector (Semiconductor)	Medical sector (Insulin)	Total
Language	English	5 (15.2%)	11 (26.8%)	9 (20.9%)	17 (48.6%)	42 (27.6%)
	Arabic	28 (25.5%)	30 (73.2%)	34 (79.1%)	18 (51.4.%)	110 (72.4%)
Participant gender:	Male	28 (84.8%)	40 (97.6%)	43 (100%)	24 (68.6%)	135 (88.8%)
	Female	5 (15.2%)	1 (2.4%)	0 (0%)	11 (31.4%)	17 (11.2%)
Level of education you have completed:	Bachelor's degree or Less	8 (24.2%)	13 (31.7%)	21 (48.8%)	7 (20%)	49 (32.2%)
	Master's degree	5 (15.2%)	12 (29.3%)	14 (32.6%)	20 (57.1%)	51 (33.6%)
	Doctoral Degree	20 (60.6%)	16 (39.0%)	8 (18.6%)	8 (22.9%)	52 (34.2%)
Years of work experience:	5 to less than 7 years	4 (12.1%)	7 (17.1%)	11 (25.6%)	11 (31.4%)	33 (21.7%)
	7 to less than 10 years	2 (6.1%)	6 (14.6%)	4 (9.3%)	5 (14.3%)	17 (11.2%)
	More than 10 years	27 (81.8%)	28 (68.3%)	28 (65.1%)	19 (54.3%)	102 (67.1%)

Table 30 (continued)

Experience background:	Practical	8 (24.2%)	8 (19.5%)	11 (25.6%)	2 (4.8%)	42 (27.6%)
	Theoretical	17 (51.5%)	21 (51.2%)	15 (34.9%)	13 (37.1%)	53 (34.9%)
	Both	8 (24.2%)	12 (29.3%)	17 (39.5%)	20 (57.1%)	57 (37.5%)

5.1.2 Data Interpretation

(1) Rice Sub-case

To measure the supply risk of rice on a national level in Saudi Arabia, experts were asked to evaluate the variables in Table 31 on a scale from one to seven. They commenced by assessing the availability and capability of rice production on a local scale, then they progressed to Saudi Arabia's external evaluation, which included the availability of the product and external suppliers' capabilities to supply the Saudi rice market.

Table 31: Rice Expert Evaluation (Supply Risk)

	(1) Extremely scarce	(2)	(3)	(4) Neutral	(5)	(6)	(7) Extremely available	Mean	SD	Trend
	Frequency Per cent (%)									
Aval. of raw materials NCMX01	11 (33.3%)	7 (21.2%)	5 (15.2%)	5 (15.2%)	3 (9.1%)	1 (3%)	1 (3%)	2.67	1.7	(2)
Aval. of feasible alternatives NCMX02	1 (3%)	3 (9.1%)	3 (9.1%)	9 (27.3%)	11 (33.3%)	2 (6.1%)	4 (12.1%)	4.45	1.5	(5)
Aval. of qualified personnel NCMX03	9 (27.3%)	10 (30.3%)	2 (6.1%)	3 (9.1%)	6 (18.2%)	3 (9.1%)	0 (0%)	2.88	1.8	(3)
Aval. of local producer NCMX05 (A)	9 (27.3%)	10 (30.3%)	4 (12.1%)	3 (9.1%)	4 (12.1%)	2 (6.1%)	1 (3%)	2.79	1.7	(3)
Aval. of investors NCMX06	4 (12.1%)	4 (12.1%)	2 (6.1%)	4 (12.1%)	1 (3%)	11 (33.3%)	7 (21.2%)	4.67	2.1	(5)
Self-sufficiency NCMX04	1 (3%)	0 (0%)	3 (9.1%)	4 (12.1%)	4 (12.1%)	11 (33.3%)	10 (30.3%)	5.51	1.5	(6)
Aval. of scientific research centres NCMX08	6 (18.2%)	8 (24.2%)	9 (27.3%)	6 (18.2%)	2 (6.1%)	2 (6.1%)	0 (0%)	2.88	1.4	(3)

Table 31 (continued)

Satisfaction of overall logistic services NCMX14	0 (0%)	0 (0%)	1 (3%)	2 (6.1%)	3 (9.1%)	14 (42.4%)	13 (39.4%)	6.09	1.0	(6)
Satisfaction of the accuracy of available data NCMX16	0 (0%)	2 (6.1%)	1 (3%)	5 (15.2%)	10 (30.3%)	11 (33.3%)	4 (12.1%)	5.18	1.3	(5)
Satisfaction of the consumption behaviour NCMX21 (A)	1 (3%)	11 (33.3%)	2 (6.1%)	3 (9.1%)	10 (30.3%)	6 (18.2%)	0 (0%)	3.85	1.7	(4)
Aval. of policies and procedures to manage the consumption behaviour NCMX21 (B)	4 (12.1%)	6 (18.2%)	2 (6.1%)	5 (15.2%)	9 (27.3%)	3 (9.1%)	4 (12.1%)	4.03	1.9	(4)
Satisfaction with the implementation of policies and procedures to manage the consumption behaviour NCMX21 (C)	5 (15.2%)	5 (15.2%)	7 (21.2%)	6 (18.2%)	5 (15.2%)	2 (6.1%)	3 (9.1%)	3.58	1.8	(4)
Easiness to Produce NCMX18 (A)	15 (45.5%)	3 (9.1%)	4 (12.1%)	4 (12.1%)	4 (12.1%)	3 (9.1%)	0 (0%)	5.36	1.8	(2)
Easiness to Store NCMX18 (B)	0 (0%)	2 (6.1%)	3 (9.1%)	1 (3%)	3 (9.1%)	10 (30.3%)	14 (42.4%)	2.24	1.6	(6)
Operational cost NCMX18 (24)	2 (6.1%)	1 (3%)	3 (9.1%)	6 (18.2%)	7 (21.2%)	6 (18.2%)	8 (24.2%)	4.97	1.7	(5)
Possibility of recycling rice after consumption?	Yes: 6 (18.1%)	No: 27 (81.8%)								
Satisfaction with the availability of policies and procedures to recycle NCMX21 (D)	4 (28.6%)	3 (21.4%)	2 (14.3%)	3 (21.4%)	2 (14.3%)	0 (0%)	0 (0%)	2.71	1.5	(2)
Satisfaction with the implementation of policies and procedures to recycle NCMX21 (E)	4 (28.6%)	5 (35.7%)	0 (0%)	3 (21.4%)	2 (14.3%)	0 (0%)	0 (0%)	2.57	1.5	(2)

Table 31 (continued)

Aval. of global supplier NCMX05 (B)	1 (3.3%)	0 (0%)	1 (3.3%)	2 (6.7%)	8 (26.7%)	11 (36.7%)	7 (23.3%)	5.57	1.3	(6)
To satisfy the local needs, does the market of Saudi Arabia rely on external suppliers for rice?	Yes: 33 (100%)	No: 0 (0%)								
External dependence NCMX07	0 (0%)	0 (0%)	1 (3.3%)	1 (3.3%)	0 (0%)	7 (23.3%)	21 (70%)	6.53	0.9	(7)
Export capacity NCMX27	0 (0%)	0 (0%)	1 (3.3%)	3 (10%)	6 (20%)	10 (33.3%)	10 (33.3%)	5.83	1.1	(6)
Trade agreement NCMX29	0 (0%)	0 (0%)	1 (3.3%)	7 (23.3%)	4 (13.3%)	13 (43.3%)	5 (16.7%)	5.47	1.1	(6)
Supply vulnerable NCMX12	0 (0%)	1 (3.3%)	2 (6.7%)	6 (20%)	6 (20%)	10 (33.3%)	5 (16.7%)	5.23	1.3	(5)
Supplier's country stability NCMX13	1 (3.3%)	2 (6.7%)	0 (0%)	8 (26.7%)	7 (23.3%)	10 (33.3%)	2 (6.7%)	4.87	1.4	(5)
Policies and procedures intervention NCMX15	1 (3.3%)	0 (0%)	4 (13.3%)	7 (23.3%)	8 (26.7%)	9 (30%)	1 (3.3%)	4.73	1.3	(5)
Market condition and structure NCMX26	2 (6.7%)	3 (10%)	4 (13.3%)	6 (20%)	7 (23.3%)	6 (20%)	2 (6.7%)	4.30	1.7	(4)
Global competition NCMX23	1 (3.3%)	1 (3.3%)	4 (13.3%)	5 (16.7%)	6 (20%)	7 (23.3%)	6 (20%)	4.97	1.6	(5)

In terms of the availability of raw materials required to farm rice in Saudi Arabia, the majority of the experts, almost 70%, agreed that there was a scarcity of the essential raw materials needed to farm rice. A smaller percentage (15%) argued that rice materials were “somewhat available” and “extremely available”. They might have been referring to the possibility of farming rice in specific parts of the country, such as Al-Hassa, where “Al-Hassawi rice” is farmed, as mentioned in section 3.3.1. However, the majority of the experts (60%) selected “somewhat difficult to extremely difficult to farm rice in Saudi Arabia”.

The availability of alternative products that could be used instead of rice was used to measure the supply risk flow of rice, as there is a feasible alternative to rice. It might not be considered a perfect substitute, but it is an acceptable one. One-third of the experts (33.3%) selected a "somewhat available" status.

The third variable aims to measure the availability of qualified personnel who can farm rice in Saudi Arabia. The most popular choices were "somewhat scarce" and "extreme scarcity of qualified personnel who can farm rice in Saudi Arabia". This might be due to the lack of farmers in Saudi Arabia, as the country is extremely reliant on external suppliers, who account for 93.3% of the suppliers. A large proportion of the available global suppliers (86.7%) are located in high level of stable countries (83.3%) and have a high level of capacity limit to supply rice to Saudi's market (86.6%). However, reliance on external suppliers brings risks due to the level of government policies and procedures that intervene in the supply of rice to other global markets (80%). The following variables were rated neutral by the majority of experts: supply vulnerable count (73.3%), global competition for rice (60%), and the most reliable suppliers' market conditions (56.6%).

Regarding the availability of scientific research centers working on a solution for the lack of rice in Saudi Arabia, this was regarded as limited. Most of the experts (70%) selected the 'scarce' option, in contrast to the overall logistic services, as 90% of the participants were satisfied with these for rice in Saudi Arabia. This might be due to the simplicity of storing the product, as most of the experts (82%) chose the option of rice being easy to store.

Just over half (57.5%) of the respondents were certain of the availability of rice investors in Saudi Arabia, and only 24.2% believed them to be scarce. Regarding self-sufficiency, more than

75% agreed that Saudi Arabia has an acceptable level of self-sufficiency for rice. That could be due to the flexibility of the trade agreements between Saudi investors and rice suppliers, as the majority (73.3%) of the participants viewed these as having a high level of flexibility, and the remaining (23.3%) were neutral in their opinion.

One-third (33.3%) of the experts were unsatisfied with the consumption behaviour related to the use of rice in Saudi Arabia. When asked about the availability and implementation of policies and procedures that control the consumption habits in Saudi Arabia, only 27.3% were somewhat satisfied, 18.2% were unsatisfied, and 30.4% were extremely dissatisfied. A small proportion (18.1%) of the experts agreed that it was possible to recycle rice, but 64.3% were dissatisfied with the rice recycling policies and procedures. The remaining 21.4% were neutral in this regard.

Meanwhile, the absence of rice at the national level was tested and to what extent it might affect the PEST factors. Table 32 summarises the experts' opinions about the hypothetical scenario of the Saudi market running out of rice.

Table 32: Rice Expert Evaluation (PEST)

	(1) No affect at all	(2)	(3)	(4) Neutral	(5)	(6)	(7) Extremely affected	Mean	SD	Trend
	Frequency Per cent (%)									
Nation's stability and security NCMY01	6 (18.2%)	6 (18.2%)	2 (6.1%)	5 (15.2%)	9 (27.3%)	4 (12.1%)	1 (3%)	3.64	1.9	(4)
Demand NCMY04	0 (0%)	0 (0%)	0 (0%)	5 (15.2%)	8 (24.2%)	8 (24.2%)	12 (36.4%)	5.82	1.1	(6)
Price stability NCMY03	0 (0%)	0 (0%)	1 (3%)	2 (6.1%)	2 (6.1%)	12 (36.4%)	16 (48.5%)	6.21	1.0	(7)
ROI NCMY06	1 (3%)	1 (3%)	1 (3%)	5 (15.2%)	12 (36.4%)	8 (24.2%)	5 (15.2%)	5.12	1.4	(5)
Public projects/services that rely on product NCMY05 (A)	4 (12.1%)	3 (9.1%)	1 (3%)	4 (12.1%)	9 (27.3%)	9 (27.3%)	3 (9.1%)	4.52	1.8	(5)

Table 32 (continued)

Local industries and businesses that rely on product NCMY05 (B)	1 (3%)	1 (3%)	1 (3%)	5 (15.2%)	9 (27.3%)	8 (24.2%)	8 (24.2%)	5.30	1.5	(6)
National macroeconomic NCMY02	7 (21.2%)	10 (30.3%)	4 (12.1 %)	9 (27.3%)	3 (9.1%)	8 (24.2%)	3 (9.1%)	2.73	1.3	(3)
Government expenses "Overfunding" NCMY07	7 (21.2%)	11 (33.3%)	8 (24.2 %)	6 (18.2 %)	1 (3%)	0 (0%)	0 (0%)	2.48	1.1	(2)
Criticality of the product to survive NCMY08	10 (30.3%)	9 (27.3%)	5 (15.2%)	6 (18.2 %)	2 (6.1%)	1 (3%)	0 (0%)	2.27	1.4	(2)
Societal attitude NCMY09	2 (6.1%)	5 (15.2%)	1 (3%)	6 (18.2%)	5 (15.2%)	7 (21.2%)	7 (21.2%)	4.70	1.9	(5)
Advancement of national technology and innovation NCMY14	12/6 (36.4%)	14 (42.4%)	2 (6.1%)	5 (15.2%)	0 (0%)	0 (0%)	0 (0%)	2	1.0	(2)

The question on national stability and security aimed to measure the political factor. Under half (42.5%) of the experts believed that a shortage of rice would have no effect on national stability and security, while 15.2% were neutral, and 27.3% believed that its absence might affect national stability and security. Regarding the demand and price stability, the majority agreed with the choice of the "affected" option, 36.4% chose "extremely affected", and 48.4% selected either "somewhat affected" or "affected". Regarding the stability of the rice price, 48.5% chose "extremely affected", and 36.4% chose "affected".

When asked about the return of government investments on rice-related projects, the majority of the experts were affected, giving the top vote "somewhat affected" (36.4%), while (24%) chose "affected". (30.4%) were between "extremely affected" and "neutral". According to (27.3%) "somewhat affected" and (48.4%) ", affected" and "extremely affected" of the experts, the absence of rice had a great effect on local businesses. This leads us to believe that rice is

considered a critical product to local public projects/services and local industries. (54.6%) were divided equally between “somewhat affected” and “affected”).

(30.3%) of experts agreed that the absence of rice has no effect on the national macroeconomy, while (27.3%) were leaning towards the” neutral” (24.2%) thought the absence has an impact, and (21.2%) were in extreme disagreement. In terms of government expenses, the majority of experts (33.3%) believed that the absence of rice was not a reason for the government over fund (24.2%) chose “somewhat no affect” (21.2%) chose “no affect at all”, and (18.2%) were “neutral”.

The experts concluded that the absence of rice products would not affect food security in Saudi Arabia. The majority (57.6%) selected “no affect at all” or “no affect,” while 18.2% thought that it would have “somewhat no affect,” and 6.1% were neutral. Similarly, with regard to advancements in national technology and innovation, 36.4% said that these would have “no effect at all” on food security, 42.4% said “no affect,” and 15.2% were neutral. However, the chance of these affecting the societal attitude was judged to be high, as 42.2% selected “extremely affected” or “affected”, while 18.2% were neutral and 15.2% chose “somewhat affected”.

(2) Gasoline Sub-case

In Saudi Arabia, the risk of interruptions to the gasoline supply flow is unlikely due to the high availability of gasoline in the country. 73.2% of the participants agreed that the raw materials required to produce gasoline in Saudi Arabia were extremely available, while 9.7% chose “somewhat available” or “available”, and 7.3% were neutral. Regarding the availability of feasible alternatives to gasoline, 29.3% of the experts were neutral. The remaining participants were divided between two opinions. A total of 36.7% believed that these were available, whilst 34.1%

believed that they were “scarce”. Regarding the availability of qualified personnel for the production of gasoline, the majority of the experts (70.7%) selected “available”, while 7.3% were “neutral”, and 19.5% chose either “somewhat scarce” or “scarce”. The majority (58.6%) fell in the range between “somewhat available” and “extremely available”, while 19.5% were neutral, and the remaining 22% believed that they were “somewhat scarce” or “scarce”. In terms of Saudi Arabia’s gasoline self-sufficiency, 53.7% of the experts opined that it was “extremely available”, whereas 19.5% selected either “somewhat available” or “available,” 9.8% were neutral, and 17.1% believed that self-sufficiency was “somewhat scarce” or “scarce”. As for the availability of scientific research centres, 65.9% believed them to be “available”, 12.2% selected “neutral”, and 21% thought that they were “somewhat scarce” or “scarce”.

Experts were asked about their satisfaction with the overall logistics services, forecasting, and managing of consumer behaviour regarding the use of gasoline in Saudi Arabia. The majority of experts (73.2%) were satisfied with the overall logistic services, while 21.9% were discontented, and 4.9%)were neutral. The experts were also asked about the accuracy of the data predicting the future: 53.7% were “somewhat satisfied,” 17.1% were “neutral,” and 29.3% were “dissatisfied”. With regard to consumption behaviour, 56.1% of the experts were neutral, “somewhat dissatisfied,” or “somewhat satisfied”. This is in line with their satisfaction with the availability of policies and procedures to manage consumption behaviour (46.6%) and their implementation (46.4%).

Regarding the complexity of producing and storing gasoline in Saudi Arabia, a little over one-third (36.6%) agreed that it was “extremely easy” to produce gasoline in Saudi Arabia, and 39% chose the responses “easy” or “neutral”. On the other hand, 43.9% agreed that it was “extremely easy” to store gasoline in Saudi Arabia, while 26.9% chose “difficult” or “extremely

difficult". When they were asked about the operational costs related to gasoline, the majority thought of these as "somewhat high" (39%) or "extremely high" (31.7%).

A large majority (82.9%) of the gasoline experts believed that the Saudi Arabian market did not rely on external suppliers of gasoline, while a few (17.1%) believed that it did. They were asked to evaluate the external gasoline suppliers, and 14.3% chose "extremely low", 42.9% chose "low", and 42.9% chose "somewhat low". In contrast, 85.7% believed that global suppliers were available, and 14.3% believed that they were somewhat scarce. 71.5% were neutral about the flexibility of trade agreements, and 42.9% of suppliers' country regime's stability to export gasoline to Saudi Arabia. In terms of the level of supply vulnerability, policy and procedure interventions, market conditions and structures, and global competition, the experts who believed that the Saudi market exclusively relies on external suppliers rated these variables as "somewhat high", 57.2% for policy and procedure interventions, 71.5% for market conditions and structure, and 71.5% for the global competition. Table 33 summarizes the experts' responses.

Table 33:Gasoline Expert Evaluation (Supply Risk)

	(1) Extremely scarce	(2)	(3)	(4) Neutral	(5)	(6)	(7) Extremely available	Mean	SD	Trend
			Frequency Per cent (%)							
Aval. of raw materials NCMX01	1 (2.4%)	0 (0%)	3 (7.3%)	3 (7.3%)	3 (7.3%)	1 (2.4%)	30 (73.2%)	6.17	1.5	(6)
Aval. of feasible alternatives NCMX02	6 (14.6%)	3 (7.3%)	5 (12.2%)	12 (29.3%)	7 (17.1%)	4 (9.8%)	4 (9.8%)	3.95	1.8	(4)
Aval. of qualified personnel NCMX03	1 (2.4%)	3 (7.3%)	5 (12.2%)	3 (7.3%)	6 (14.6%)	11 (26.8%)	12 (29.3%)	5.22	1.8	(5)
Aval. of local producer NCMX05 (A)	1 (2.4%)	2 (4.9%)	5 (12.2%)	5 (12.2%)	5 (12.2%)	6 (14.6%)	17 (41.5%)	5.37	1.8	(6)
Aval. of investors NCMX06	1 (2.4%)	4 (9.8%)	4 (9.8%)	8 (19.5%)	3 (7.3%)	9 (22%)	12 (29.3%)	5.02	1.8	(5)
Self-sufficiency NCMX04	0 (0%)	5 (12.2%)	2 (4.9%)	4 (9.8%)	2 (4.9%)	6 (14.6%)	22 (53.7%)	5.66	1.8	(6)

Table 33 (continued)

Aval. of scientific research centres NCMX08	0 (0%)	3 (7.3%)	6 (14.6%)	5 (12.2%)	9 (22%)	6 (14.6%)	12 (29.3%)	5.10	1.7	(5)
Satisfaction of overall logistic services NCMX14	1 (2.4%)	3 (7.3%)	5 (12.2%)	2 (4.9%)	5 (12.2%)	8 (19.5%)	17 (41.5%)	5.41	1.8	(6)
Satisfaction of the accuracy of available data NCMX16	2 (4.9%)	5 (12.2%)	5 (12.2%)	7 (17.1%)	7 (17.1%)	10 (24.4%)	5 (12.2%)	4.51	1.8	(5)
Satisfaction of the consumption behaviour NCMX21 (A)	4 (9.8%)	8 (19.5%)	5 (12.2%)	6 (14.6%)	12 (29.3%)	4 (9.8%)	2 (4.9%)	3.83	1.7	(4)
Aval. of policies and procedures to manage the consumption behaviour NCMX21 (B)	1 (2.4%)	9 (22%)	3 (7.3%)	6 (14.6%)	10 (24.4%)	10 (24.4%)	2 (4.9%)	4.30	1.7	(4)
Satisfaction with the implementation of policies and procedures to manage the consumption behaviour NCMX21 (C)	3 (7.3%)	7 (17.1%)	3 (7.3%)	7 (17.1%)	9 (22%)	9 (22%)	3 (7.3%)	4.24	1.8	(4)
Easiness to Produce NCMX18 (A)	15 (36.6%)	7 (17.1%)	6 (14.6%)	3 (7.3%)	3 (7.3%)	4 (9.8%)	3 (7.3%)	2.90	2.0	(3)
Easiness to Store NCMX18 (B)	18 (43.9%)	3 (7.3%)	4 (9.8%)	3 (7.3%)	2 (4.9%)	4 (9.8%)	7 (17.1%)	3.20	2.4	(3)
Operational cost NCMX18 (24)	5 (12.2%)	2 (4.9%)	5 (12.2%)	5 (12.2%)	3 (7.3%)	8 (19.5%)	13 (31.7%)	4.83	2.1	(5)
Possibility of recycling gasoline after consumption?	Yes: 0 (0%)	No: 41 (100%)								
Satisfaction with the availability of policies and procedures to recycle NCMX21 (D)	-	-	-	-	-	-	-	-	-	-
Satisfaction with the implementation of policies and procedures to recycle NCMX21 (E)	-	-	-	-	-	-	-	-	-	-
Aval. of global supplier NCMX05 (B)	0 (0%)	0 (0%)	1 (14.3%)	0 (0%)	2 (28.6%)	0 (0%)	4 (57.1%)	5.86	1.57	(6)

Table 33 (continued)

To satisfy the local needs, does the market of Saudi Arabia rely on external suppliers for gasoline?	Yes: 7 (17.1%)	No: 34 (82.9%)								
External dependence NCMX07	1 (14.3%)	3 (42.9%)	3 (42.9%)	0 (0%)	0 (0%)	0 (%)	0 (0%)	2.29	0.75	(2)
Export capacity NCMX27	0 (0%)	1 (14.3%)	1 (14.3%)	2 (28.6%)	2 (28.6%)	1 (14.3%)	0 (0%)	4.14	1.34	(4)
Trade agreement NCMX29	0 (6.7%)	1 (14.3%)	2 (28.6%)	2 (28.6%)	1 (14.3%)	1 (14.3%)	0 (0%)	3.86	1.34	(4)
Supply vulnerable NCMX12	1 (14.3%)	0 (0%)	1 (14.3%)	0 (0%)	2 (28.6%)	2 (28.6%)	1 (14.3%)	4.71	2.05	(5)
Supplier's country stability NCMX13	0 (0%)	2 (28.6%)	0 (0%)	1 (14.3%)	2 (28.6%)	1 (14.3%)	1 (14.3%)	4.43	1.90	(4)
Policies and procedures intervention NCMX15	0 (0%)	1 (14.3%)	0 (0%)	1 (14.3%)	2 (28.6%)	1 (14.3%)	2 (28.6%)	5.14	1.77	(5)
Market condition and structure NCMX26	0 (0%)	1 (14.3%)	0 (0%)	1 (14.3%)	2 (28.6%)	2 (28.6%)	1 (14.3%)	5	1.63	(5)
Global competition NCMX23	1 (14.3%)	0 (0%)	0 (0%)	0 (0%)	2 (28.6%)	3 (42.9%)	1 (14.3%)	5.14	1.95	(5)

The experts were asked to express their thoughts and evaluations through a seven-point Likert scale about the hypothetical scenario where the market of Saudi Arabia ran out of gasoline or experienced a supply shortage. One quarter (24.4%) believed that national stability and security would be “extremely affected”, while 41.5% chose “neutral” or “affected”, and 34.2% selected “somewhat not affected” or “extremely not affected at all”. The majority (60.9%) believed that the demand for gasoline would be “affected”, while 24.4% believed that it would not, and 4.9% were neutral. Similar to the responses for gasoline prices, the majority of experts (70.7%) leaned towards the “affected” side. Regarding the return on government investment, 43.9% believed that it would be “extremely affected” by a shortage of gasoline, 24.4% chose “somewhat affected” or “affected”, 12.2% were neutral, and 19.5% leaned towards “unaffected”. In terms of public projects and services that rely on gasoline, as well as local businesses, the majority of experts (73.3%) believed

that public projects and services would be “affected”, 12.2% were neutral, and 14.7% thought that these services and projects would “not be affected” by a shortage of gasoline. Regarding local businesses, 68.4% believed that they would be “affected”, 9.8% were neutral, and 22% believed that they would “not be affected”. Regarding the national macroeconomy, the majority (56.1%) were neutral. In terms of government expenses that might occur during a shortage of gasoline, 46.4% of experts agreed that they would be “somewhat affected”, while 34.1% believed that they would be “extremely affected”. Around one-third, (34.1%) of the experts were adamant that gasoline was critical for survival, while 31.7% believed that it was “somewhat critical”, and 34.2% thought that it was not critical at all. As for societal attitude, 48.9% believed that a gasoline shortage would “somewhat affect” societal attitude, 24.4% believed it would be “extremely affected”, and 26.8% thought that there would be no effect on societal attitude. Regarding the question of whether a shortage of gasoline would affect the future of technology and innovation in Saudi Arabia, 53% of the experts claimed that it would, 19.5% were highly convinced that it would, and 26.9% disagreed.

Table 34: Gasoline Expert Evaluation (PEST)

	(1) No affect at all	(2)	(3)	(4) Neutral	(5)	(6)	(7) Extremely affected	Mean	SD	Trend
	Frequency Per cent (%)									
Nation's stability and security NCMY01	2 (4.9%)	7 (17.1%)	5 (12.2%)	7 (17.1%)	7 (17.1%)	3 (7.3%)	10 (24.4%)	4.44	1.9	(5)
Demand NCMY04	1 (2.4%)	5 (12.2%)	4 (9.8%)	2 (4.9%)	4 (9.8%)	6 (14.6%)	19 (46.3%)	5.37	2.0	(6)
Price stability NCMY03	2 (4.9%)	3 (7.3%)	4 (9.8%)	3 (7.3%)	2 (4.9%)	6 (14.6%)	21 (51.2%)	5.49	2.0	(6)
ROI NCMY06	3 (7.3%)	2 (4.9%)	3 (7.3%)	5 (12.2%)	4 (9.8%)	6 (14.6%)	18 (43.9%)	5.32	2.0	(6)
Public projects/services that rely on product NCMY05 (A)	0 (0%)	2 (4.9%)	4 (9.8%)	5 (12.2%)	4 (9.8%)	9 (22%)	17 (41.5%)	5.59	1.6	(6)

Table 34 (continued)

Local industries and businesses that rely on product NCMY05 (B)	2 (4.9%)	2 (4.9%)	5 (12.2%)	4 (9.8%)	2 (4.9%)	9 (22%)	17 (41.5%)	5.37	1.9	(6)
National macroeconomic NCMY02	3 (7.3%)	6 (14.6%)	6 (14.6%)	8 (19.5%)	9 (22%)	2 (4.9%)	7 (17.1%)	4.17	1.8	(4)
Government expenses "Overfunding" NCMY07	1 (2.4%)	3 (7.3%)	4 (9.8%)	5 (12.2%)	4 (9.8%)	10 (24.4%)	14 (34.1%)	5.29	1.8	(5)
Criticality of the product to survive NCMY08	4 (9.8%)	4 (9.8%)	6 (14.6%)	3 (7.3%)	5 (12.2%)	5 (12.2%)	14 (34.1%)	4.8	2	(5)
Societal attitude NCMY09	1 (2.4%)	3 (7.3%)	7 (17.1%)	7 (17.1%)	4 (9.8%)	9 (22%)	10 (24.4%)	4.88	1.8	(5)
Advancement of national technology and innovation NCMY14	3 (7.3%)	4 (9.8%)	4 (9.8%)	8 (19.5%)	8 (19.5%)	6 (14.6%)	8 (19.5%)	4.56	1.9	(5)

(3) Semiconductor Sub-case

In order to produce semiconductors in Saudi Arabia, one of the elements that Saudi experts (53.4%) consider critical is "scarce", and an additional (9.3%) who believed it's "extremely scarce". In terms of other available semiconductors alternatives, (51.2%) answered scarce, while (9.3%) believed it's "extremely scarce". (51.2%) of statistics indicate a "scarcity" in qualified personnel; however, (35%) felt that there "available" with a total percentage of (65.1%), whereas (11.6%) were "neutral", and (23.3%) were in between "somewhat available" and "available". Investors who are willing to invest in semiconductors are "scarce" as well, (62.8%) agreed on the unwillingness of investors, (14%) were neutral, and (23.3%) chose "available". Regarding self-sufficiency, (83.8%) of the experts agreed on its "scarcity" with different levels, whereas (16.3%) agreed on availability. The scientific research in Saudi Arabia seems to be limited as since (76.8%) of the experts were leaning towards the "scarcity" side, and (23.2%) were in between "somewhat available" and "available".

In terms of experts' satisfaction, (27.9%) of experts were "extremely dissatisfied" with the overall logistic services related to semiconductors products, (41.8%) were "somewhat dissatisfied," and (30.2%) were "satisfied" with different levels. (81.5%) were "dissatisfied" and "extremely dissatisfied" with the availability of accurate data about future needs. Experts were not in agreement with the behaviour of semiconductor usage in Saudi Arabia. (65.1%) were "dissatisfied", and (20.9%) were "extremely dissatisfied".

When asked about their satisfaction with the available policies and procedures and how they are being implemented in Saudi Arabia, (67.5%) were unsatisfied with the available policies and procedures and (65.1%) were not satisfied with the implementation being used to manage the consumption behaviour.

In terms of how complex it is to produce and store semiconductors in Saudi Arabia, the majority of experts (51.2%) believed to be "difficult", (18.6%) "extremely difficult," and (30.3%) leaned towards easiness to produce semiconductors in Saudi Arabia. In regard to the complexity of storing semiconductors, the majority of experts (65.1%) were leaning towards easy; however, (27.9%) believed it's "somewhat difficult" with "neutral" operational cost (60.5%).

It has been proven that semiconductors are recyclable by (86%) of experts. However, in terms of the available policies and procedures and the implementation, the majority (43.2%) of them were more "dissatisfied", (27%) were "extremely dissatisfied," and (29.7%) were "somewhat satisfied". Regarding the implementation of these policies and procedures, (48.6%) were "somewhat dissatisfied," (27%) were "extremely dissatisfied". In contrast, 24.3% were satisfied.

The experts confirmed that Saudi Arabia relies heavily on external semiconductor suppliers (100%). When they were asked about the ratio of external reliance, (48.8%) said it was "extremely

high," and (25.6%) were in between "high" and "somewhat high". However, that meets with the limited availability of global suppliers as (44.2%) believed they were scarce, (41.9%) believed they were "available", and (14%) were neutral. The capacity limit of suppliers supplying Saudi's market with semiconductors is "somewhat available" (60.5%), and (14%) said they're "extremely available". In terms of the flexibility of the trade agreement between Saudi's parties and the most reliable suppliers, (79.1%) of the experts were leaning towards "somewhat flexible," and (14%) said, "extremely flexible". However, the flow of supply is considered highly vulnerable, as confirmed by (67.4%), whereas (18.6%) disagree with them. (14%) were neutral; with regard to market conditions and structures, the majority of experts were neutral (72%). In terms of policies and procedures intervention that hamper semiconductors' supply, (65.1%) believed it was "somewhat high," and (18.6 %) "extremely agreed" with them. Regarding the stability of supplier countries, the majority of experts agreed that they have a "somewhat high" stability, with a total percentage of (69.8%). The global competition of semiconductors is "high". A total of (53.5%) were between "high" and "extremely high", whereas (20.9%) were "neutral". Table 35 summarises the semiconductor result.

Table 35: Semiconductor Expert Evaluation (Supply Risk)

	(1) Extremely scarce	(2)	(3)	(4) Neutral	(5)	(6)	(7) Extremely available	Mean	SD	Trend
			Frequency Per cent (%)							
Aval. of raw materials NCMX01	4 (9.3%)	9 (20.9%)	5 (11.6%)	9 (20.9%)	5 (11.6%)	6 (14%)	5 (11.6%)	3.93	1.9	(4)
Aval. of feasible alternatives NCMX02	4 (9.3%)	13 (30.2%)	5 (11.6%)	9 (20.9%)	7 (16.3%)	2 (4.7%)	3 (7%)	3.47	1.7	(3)
Aval. of qualified personnel NCMX03	6 (14%)	7 (16.3%)	10 (23.3%)	5 (11.6%)	10 (23.3%)	3 (7%)	2 (4.7%)	3.53	1.7	(3)
Aval. of local producer NCMX05 (A)	12 (27.9%)	11 (25.6%)	5 (11.6%)	5 (11.6%)	7 (16.3%)	3 (7%)	0 (0%)	2.84	1.7	(3)

Table 35 (continued)

Aval. of investors NCMX06	10 (23.3%)	13 (30.2%)	4 (9.3%)	6 (14%)	6 (14%)	3 (7%)	1 (2.3%)	2.95	1.7	(3)
Self-sufficiency NCMX04	12 (27.9%)	10 (23.3%)	4 (9.3%)	10 (23.3%)	5 (11.6%)	2 (4.7%)	0 (0%)	2.81	1.6	(3)
Aval. of scientific research centres NCMX08	11 (25.6%)	11 (25.6%)	4 (9.3%)	7 (16.3%)	5 (11.6%)	5 (11.6%)	0 (0%)	2.98	1.7	(3)
Satisfaction of overall logistic services NCMX14	12 (27.9%)	4 (9.3%)	9 (20.9%)	5 (11.6%)	9 (20.9%)	1 (2.3%)	3 (7%)	3.23	1.9	(3)
Satisfaction of the accuracy of available data NCMX16	10 (23.3%)	6 (14%)	11 (25.6%)	8 (18.6%)	6 (14%)	2 (4.7%)	0 (0%)	3.00	1.5	(3)
Satisfaction of the consumption behaviour NCMX21 (A)	9 (20.9%)	8 (18.6%)	11 (25.6%)	9 (20.9%)	4 (9.3%)	2 (4.7%)	0 (0%)	2.93	1.4	(3)
Aval. of policies and procedures to manage the consumption behaviour NCMX21 (B)	9 (20.9%)	13 (30.2%)	6 (14%)	10 (23.3%)	5 (11.6%)	0 (0%)	0 (0%)	2.74	1.3	(3)
Satisfaction with the implementation of policies and procedures to manage the consumption behaviour NCMX21 (C)	9 (20.9%)	12 (27.9%)	7 (16.3%)	9 (20.9%)	5 (11.6%)	1 (2.3%)	0 (0%)	2.81	1.4	(3)
Easiness to Produce NCMX18 (A)	1 (2.3%)	2 (4.7%)	10 (23.3%)	8 (18.6%)	10 (23.3%)	4 (9.3%)	8 (18.6%)	4.58	1.6	(5)
Easiness to Store NCMX18 (B)	3 (7%)	9 (20.9%)	8 (18.6%)	11 (25.6%)	9 (20.9%)	0 (0%)	3 (7%)	3.60	1.5	(3)
Operational cost NCMX18 (24)	3 (7%)	2 (4.7%)	9 (20.9%)	7 (16.3%)	10 (23.3%)	6 (14%)	6 (14%)	4.42	1.7	(4)
Possibility of recycling semiconductors after consumption?	Yes: 37 (86%)	No: 6 (14%)								
Satisfaction with the availability of policies and procedures to recycle NCMX21 (D)	10 (27%)	5 (13.5%)	7 (18.9%)	4 (10.8%)	8 (21.6%)	2 (5.4%)	1 (2.7%)	3.14	1.8	(3)
Satisfaction with the implementation of policies and procedures to recycle NCMX21 (E)	10 (27%)	6 (16.2%)	6 (16.2%)	6 (16.2%)	5 (13.5%)	2 (5.4%)	2 (5.4%)	3.11	1.8	(3)
Aval. of global supplier NCMX05 (B)	0 (0%)	5 (11.6%)	14 (32.6%)	6 (14%)	8 (18.6%)	6 (14%)	4 (9.3%)	4.19	1.5	(4)

Table 35 (continued)

To satisfy the local needs, does the market of Saudi Arabia rely on external suppliers for semiconductors?	Yes: 43 (100%)	No: 0 (0%)								
External dependence NCMX07	0 (0%)	2 (4.7%)	4 (9.3%)	5 (11.6%)	5 (11.6%)	6 (14%)	21 (48.8%)	5.67	1.6	(6)
Export capacity NCMX27	0 (0%)	3 (7%)	8 (18.6%)	10 (23.3%)	8 (18.6%)	8 (18.6%)	6 (14%)	4.65	1.5	(5)
Trade agreement NCMX29	1 (2.3%)	0 (0%)	4 (9.3%)	17 (39.5%)	10 (23.3%)	7 (16.3%)	4 (9.3%)	4.67	1.3	(5)
Supply vulnerable NCMX12	1 (2.3%)	1 (2.3%)	6 (14%)	6 (14%)	4 (9.3%)	9 (20.9%)	16 (37.2%)	5.37	1.7	(6)
Supplier's country stability NCMX13	0 (0%)	2 (4.7%)	5 (11.6%)	14 (32.6%)	9 (20.9%)	7 (16.3%)	6 (14%)	4.74	1.4	(5)
Policies and procedures intervention NCMX15	1 (2.3%)	0 (0%)	6 (14%)	9 (20.9%)	9 (20.9%)	10 (23.3%)	8 (18.6%)	5.02	1.5	(5)
Market condition and structure NCMX26	1 (2.3%)	1 (2.3%)	9 (20.9%)	13 (30.2%)	9 (20.9%)	7 (16.3%)	3 (7%)	4.42	1.4	(4)
Global competition NCMX23	0 (0%)	1 (2.3%)	7 (16.3%)	9 (20.9%)	3 (7%)	12 (27.9%)	11 (25.6%)	5.19	1.5	(5)

Table 36 summarises the result of studying the impact on Saudi's market during the absence of semiconductors. The majority of experts (58.1%) were neutral when asked about the impact of semiconductors on national stability and security, whereas (23.2%) were in between "high" and "extremely high", unlike (18.6%) who believed it does not have an impact. The shortage of semiconductors will affect the demand as (59.5%) "somewhat affect" the demand and (20.9%) it's "extremely affected the demand" said. In contrast, (18.6%) believed it won't. Results are almost the same for price stability, (65.2%) said it's "somewhat affected," (23.3%) were "extremely affected," and (11.6%) leaned more towards the unaffected side. In regards to the return on government investment on projects related to semiconductors, (76.8%) were leaning towards "somewhat affected," (9.3%) being "extremely affected," and a small percentage (13.6%) thought it would not be affected. Aligning with that, the public projects/services and local businesses are

affected too, (65.2%) said it's "somewhat affected", and (69.7%) for local businesses. Regarding the national macroeconomy, most experts rank it as neutral (62.8%), whereas (16.3%) think it's likely to be affected, and (21%) lean towards the unaffected side. It appears that the shortage of semiconductors resulted in government overfunding as (62.8%) believed that it would "somewhat be affected," (16.3%) said it was "extremely affected," and (20.9%) leaned more towards the unaffected side. In terms of the criticality of the product for survival, semiconductors seem to be a critical component since (67.5%) agreed on that and ranked it as somewhat affected, and (11.6%) said it has an extreme impact similar to the advancement of national technology and innovation. (83.7%) believed that it would be affected. Regarding societal attitudes, the majority of experts were neutral (65.2%).

Table 36: Semiconductor Expert Evaluation (PEST)

	(1) No affect at all	(2)	(3)	(4) Neutral	(5)	(6)	(7) Extremely affected	Mean	SD	Trend
	Frequency Per cent (%)									
Nation's stability and security NCMY01	3 (7%)	5 (11.6%)	7 (16.3%)	9 (20.9%)	9 (20.9%)	5 (11.6%)	5 (11.6%)	4.19	1.7	(4)
Demand NCMY04	1 (2.3%)	1 (2.3%)	6 (14%)	5 (11.6%)	9 (20.9%)	12 (27.9%)	9 (20.9%)	5.14	1.6	(5)
Price stability NCMY03	1 (2.3%)	3 (7%)	1 (2.3%)	6 (14%)	8 (18.6%)	14 (32.6%)	10 (23.3%)	5.30	1.6	(5)
ROI NCMY06	1 (2.3%)	0 (0%)	5 (11.6%)	14 (32.6%)	9 (20.9%)	10 (23.3%)	4 (9.3%)	4.77	1.3	(5)
Public projects/services that rely on product NCMY05 (A)	1 (2.3%)	4 (9.3%)	4 (9.3%)	11 (25.6%)	11 (25.6%)	6 (14%)	6 (14%)	4.6	1.6	(5)
Local industries and businesses that rely on product NCMY05 (B)	1 (2.3%)	1 (2.3%)	7 (16.3%)	12 (27.9%)	9 (20.9%)	9 (20.9%)	4 (9.3%)	4.63	1.4	(5)
National macroeconomic NCMY02	6 (14%)	3 (7%)	6 (14%)	17 (39.5%)	4 (9.3%)	5 (11.6%)	2 (4.7%)	3.77	1.6	(4)
Government expenses "Overfunding" NCMY07	1 (2.3%)	1 (2.3%)	7 (16.3%)	9 (20.9%)	11 (25.6%)	7 (16.3%)	7 (16.3%)	4.79	1.5	(5)

Table 36 (continued)

Criticality of the product to survive NCMY08	1 (2.3%)	3 (7%)	5 (11.6%)	12 (27.9%)	11 (25.6%)	6 (14%)	5 (11.6%)	4.56	1.5	(5)
Societal attitude NCMY09	4 (9.3%)	4 (9.3%)	6 (14%)	15 (34.9%)	7 (16.3%)	4 (9.3%)	3 (7%)	3.95	1.6	(4)
Advancement of national technology and innovation NCMY14	1 (2.3%)	2 (4.7%)	4 (9.3%)	10 (23.3%)	4 (9.3%)	9 (20.9%)	13 (30.2%)	5.16	1.7	(5)

(4) Insulin Sub-case

In order to evaluate the level of insulin supply risk in Saudi Arabia, experts were asked to assess the following variables on a scale from 1 to 7. According to the results, there appears to be difficulty with the production of insulin in Saudi Arabia due to the scarcity of the most important elements. The availability of required raw materials is nearly extremely scarce, as (68.6%) suggest. A few (11.5%) believed the resources to be available.

What makes insulin more critical is that there is no other alternative that could be used in its absence. (57.1%) said they're "extremely scarce," and (31.5%) said they're "scarce." Regarding the availability of qualified personnel who obtain the knowledge and experience required for the production of a product, expert opinions were varied. The majority were in between "somewhat scarce" to "somewhat available", with a total percentage of (51.4%). However, (22.8%) were certain about their scarcity. In contrast, (11.4%) believed that they were available. In Saudi Arabia, local producers are limited, as proven by (57.1% of) those who voted were in between "scarce" and "extremely scarce," while (20%) voted on their "availability" (and 11.4%) were neutral. In terms of available investors who are willing to invest in insulin, (37.2%) of the experts believed that they are "scarce", while the remaining experts were varied. (37.2%) were "neutral", and (25.7%) believed they were available. Regarding the rate of self-sufficiency, (42.9%) of the experts were neutral, whereas (28.6%) felt its "scarce," while (28.5%) were in opposition. Although

scientific research has made a great contribution to solving the shortage of insulin in Saudi Arabia, it still appears to be limited as a bigger percentage (51.4%) believed that there was a “scarcity” in research. In comparison (31.4%) thought that it’s “available”, and (17.1%) were neutral.

There was (a 65%) satisfaction rate from the overall logistic services and facilities handling insulin, while (14.3%) were neutral. Regarding predicting future demand, (34.3%) were satisfied with the predictions, and (14.3%) were somewhat satisfied. On the other hand, nearly (28%) were dissatisfied with the accuracy of the available data with regard to the use of insulin by consumers and the available policies and procedures and their implementations that limit insulin wasting. The majority of experts (42.8%) were “somewhat satisfied” to “satisfied” with the consumption behavior. No expert was “extremely satisfied”. On the other hand, (37.1%) were more “dissatisfied,” and (20%) were neutral. The satisfaction on the available policies and procedures and their implementation. (42.9%) were leaning towards dissatisfied, and (45.8%) for its implementation. In contrast, (21.1%) were in between “somewhat satisfied” and “extremely satisfied” with the available policies and procedures, which was close to the implementation satisfaction rate of (28.6%).

Insulin seems to be challenging to produce in Saudi Arabia and simple to store. (65.7%) were in the range of “somewhat difficult” to “extremely difficult to store”, while a few experts were in between “somewhat easy” (14.3%) and “easy” (11.4%). In terms of storing insulin, (65.8%) were more inclined to the more accessible side, but (28.6%) believed it was difficult to keep insulin in Saudia Arabia. However, the operational costs of handling insulin appear to be high, as (77.2%) confirmed, while a small percentage of experts (17.1%) have different opinions. What makes insulin more finite is the impossibility of its reprocessing after being consumed, as confirmed by (100%) of experts.

To satisfy the local needs of insulin in Saudi Arabia, the market heavily relies on global insulin suppliers. (94.3%) of the participants confirmed that. Therefore, evaluating external supply is needed. (77.1%) believed that the level of global suppliers' availability is "high," unlike the (14.3%) who believed they were low. What lowers the risk of running out of insulin supply is the capacity limit of the global suppliers, the flexibility of trade agreements, and the stability of the supplier's country. (60%) of the experts were leaning toward the "higher level", while (14.3%) believed it was "somewhat low". Similar to the trade agreement between Saudi parties and insulin suppliers, (71.5%) of the experts were leaning toward higher flexibility, while (20%) were neutral, and (8.6%) were between "somewhat low" and "low". In terms of the supplying country's stability, (68.5%) said it's fairly stable. As for global competition, (68.6%) believed it was "high," (20%) was disagreed, and (11.4%) were neutral. The market condition and structure of insulin were varied. (37.1%) believed it has the lower risks, (20%) were neutral, and (42.8%) leaned more towards a higher level of risk. Regarding supply vulnerable level and policy and procedures intervention, the majority of experts were neutral.

Table 37: Insulin Expert Evaluation (Supply Risk)

	(1) Extremely scarce	(2)	(3)	(4) Neutral	(5)	(6)	(7) Extremely available	Mean	SD	Trend
			Frequency Per cent (%)							
Aval. of raw materials NCMX01	15 (42.9%)	9 (25.7%)	3 (8.6%)	4 (11.4%)	3 (8.6%)	1 (2.9%)	0 (0%)	2.26	1.5	(2)
Aval. of feasible alternatives NCMX02	20 (57.1%)	8 (22.9%)	3 (8.6%)	2 (5.7%)	2 (5.7%)	0 (0%)	0 (0%)	1.8	1.2	(1)
Aval. of qualified personnel NCMX03	2 (5.7%)	6 (17.1%)	4 (11.4%)	7 (20%)	7 (20%)	5 (14.3%)	4 (11.4%)	4.20	1.7	(4)
Aval. of local producer NCMX05 (A)	7 (20%)	13 (37.1%)	4 (11.4%)	4 (11.4%)	2 (5.7%)	4 (11.4%)	1 (2.9%)	2.91	1.7	(3)
Aval. of investors NCMX06	3 (8.6%)	10 (28.6%)	5 (14.3%)	3 (8.6%)	5 (14.3%)	4 (11.4%)	5 (14.3%)	3.83	2	(4)

Table 37 (continued)

Self-sufficiency NCMX04	0 (0%)	10 (28.6%)	5 (14.3%)	5 (14.3%)	5 (14.3%)	6 (17.1%)	4 (11.4%)	4.11	1.8	(4)
Aval. of scientific research centres NCMX08	4 (11.4%)	12 (34.3%)	2 (5.7%)	6 (17.1%)	4 (11.4%)	5 (14.3%)	2 (5.7%)	3.49	1.8	(3)
Satisfaction of overall logistic services NCMX14	1 (2.9%)	3 (8.6%)	3 (8.6%)	5 (14.3%)	9 (25.7%)	7 (20%)	7 (20%)	4.9	1.6	(5)
Satisfaction of the accuracy of available data NCMX16	1 (2.9%)	3 (8.6%)	7 (20%)	5 (14.3%)	5 (14.3%)	12 (34.3%)	2 (5.7%)	4.54	1.6	(5)
Satisfaction of the consumption behaviour NCMX21 (A)	2 (5.7%)	5 (17.1%)	5 (14.3%)	7 (20%)	11 (31.4%)	4 (11.4%)	0 (0%)	3.89	1.4	(4)
Aval. of policies and procedures to manage the consumption behaviour NCMX21 (B)	3 (8.6%)	5 (14.3%)	7 (20%)	7 (20%)	6 (17.1%)	6 (17.1%)	1 (2.9%)	3.86	1.6	(4)
Satisfaction with the implementation of policies and procedures to manage the consumption behaviour NCMX21 (C)	3 (8.6%)	8 (22.9%)	5 (14.3%)	9 (25.7%)	5 (14.3%)	2 (5.7%)	3 (8.6%)	3.66	1.7	(4)
Easiness to Produce NCMX18 (A)	0 (0%)	4 (11.4%)	5 (14.3%)	3 (8.6%)	7 (20%)	7 (20%)	9 (25.7%)	5	1.7	(5)
Easiness to Store NCMX18 (B)	8 (22.9%)	8 (22.9%)	7 (20%)	2 (5.7%)	4 (11.4%)	5 (14.3%)	1 (2.9%)	3.14	1.9	(3)
Operational cost NCMX18 (24)	2 (5.7%)	2 (5.7%)	2 (5.7%)	2 (5.7%)	8 (22.9%)	5 (14.3%)	14 (40%)	5.37	1.9	(6)
Possibility of recycling insulin after consumption?	Yes: 0 (0%)	No: 35 (100%)								
Satisfaction with the availability of policies and procedures to recycle NCMX21 (D)	-	-	-	-	-	-	-	-	-	-
Satisfaction with the implementation of policies and procedures to recycle NCMX21 (E)	-	-	-	-	-	-	-	-	-	-
Aval. of global supplier NCMX05 (B)	0 (0%)	1 (2.9%)	4 (11.4%)	3 (8.6%)	8 (22.9%)	13 (37.1%)	6 (17.1%)	5.31	1.3	(6)

Table 37 (continued)

To satisfy the local needs, does the market of Saudi Arabia rely on external suppliers for insulin?	Yes: 35 (100%)	No: 0 (0%)								
External dependence NCMX07	0 (0%)	0 (0%)	2 (5.7%)	0 (0%)	6 (17.1%)	3 (8.6%)	24 (68.6%)	6.34	1.1	(7)
Export capacity NCMX27	0 (0%)	0 (0%)	5 (14.3%)	9 (25.7%)	7 (20%)	10 (28.6%)	4 (11.4%)	5	1.3	(5)
Trade agreement NCMX29	0 (0%)	1 (2.9%)	2 (5.7%)	7 (20%)	10 (28.6%)	8 (22.9%)	7 (20%)	5.23	1.3	(5)
Supply vulnerable NCMX12	2 (5.7%)	4 (11.4%)	4 (11.4%)	11 (31.4%)	7 (20%)	6 (17.1%)	1 (2.9%)	4.11	1.5	(4)
Supplier's country stability NCMX13	0 (0%)	1 (2.9%)	2 (5.7%)	8 (22.9%)	5 (14.3%)	13 (37.1%)	6 (17.1%)	5.29	1.3	(5)
Policies and procedures intervention NCMX15	0 (0%)	5 (14.3%)	7 (20%)	7 (20%)	5 (14.3%)	8 (22.9%)	3 (8.6%)	4.37	1.6	(4)
Market condition and structure NCMX26	6 (17.1%)	4 (11.4%)	3 (8.6%)	7 (20%)	7 (20%)	4 (11.4%)	4 (11.4%)	3.94	1.9	(4)
Global competition NCMX23	2 (5.7%)	2 (5.7%)	3 (8.6%)	4 (11.4%)	12 (34.3%)	4 (11.4%)	8 (22.9%)	4.9	1.7	(5)

During the absence of insulin, most of the selected impacted factors will be affected. It will have an impact on the national stability and security. (25.7%) of the study's experts extremely agreed with this statement. (22.9%) were between "somewhat affected" and "affected". (25.7%) were either neutral or believed that the absence did not have an impact.

(88.5%) of experts confirmed that the demand on insulin will be affected. In terms of price stability, (40%) of the experts said that the price will be "extremely affected" (31.5%) between "somewhat affected" and "affected." In contrast, there were a few experts (20%) leaning towards the "unaffected" side, and the remaining (8.6%) were neutral. When it came to the return on investment, (22.9%) were neutral, whereas (37.2%) chose "affected," and (28.5%) disagreed with them. For public projects/services and local businesses that rely on insulin products, (51.5%) of the experts were on the affected side, (22.9%) were neutral, and (25.7%) believed that the public

projects/services would not be affected. With regard to the local businesses, (34.3%) said they were extremely affected, (40%) were in between “somewhat affected” and “affected,” (20%) of the experts were neutral. A very small percentage (5.7%) thought it might “not affect”. When asked about the national macroeconomy, the majority of experts were attracted towards the “affected” side. (17.1%) said “extremely affected,” (25.7%) “affected,” (22.9%) “somewhat affected,” (22.9%) were neutral, and very few experts (11.5%) believed it does not have an impact. In terms of overfunding that might be a consequence of the absence of insulin, (28.6%) think it’s neutral; however, (54.3%) went with “affected,” and (17.2%) believed it would not have an impact. Regarding the criticality of the product to survival, the majority said it’s “extremely affected”, with an additional (25.7%) who believed it would be “affected.” (11.4%) were neutral, and (11.5%) thought it would not have an impact at all. Regarding societal attitude, (31.4%) were neutral, and the remaining scales were almost equally distributed. Regarding the advancement of technology and national innovation, (28.6%) were neutral, (51.5%) believed that the absence has an impact on national technology and innovation, whereas (20%) disagreed with them.

Table 38: Insulin Expert Evaluation (PEST)

	(1) No affect at all	(2)	(3)	(4) Neutral	(5)	(6)	(7) Extremely affected	Mean	SD	Trend
	Frequency Per cent (%)									
Nation's stability and security NCMY01	1 (2.9%)	6 (17.1%)	2 (5.7%)	9 (25.7%)	3 (8.6%)	5 (14.3%)	9 (25.7%)	4.66	2	(5)
Demand NCMY04	0 (0%)	2 (5.7%)	0 (0%)	2 (5.7%)	4 (11.4%)	7 (20%)	20 (57.1%)	6.11	1.4	(6)
Price stability NCMY03	4 (11.4%)	2 (5.7%)	1 (2.9%)	3 (8.6%)	8 (22.9%)	3 (8.6%)	14 (40%)	5.11	2	(5)
ROI NCMY06	2 (5.7%)	4 (11.4%)	4 (11.4%)	8 (22.9%)	5 (14.3%)	5 (14.3%)	8 (22.9%)	4.7	1.8	(5)
Public projects/services that rely on product NCMY05 (A)	1 (2.9%)	4 (11.4%)	4 (11.4%)	8 (22.9%)	5 (14.3%)	5 (14.3%)	8 (22.9%)	4.7	1.8	(5)

Table 38 (continued)

Local industries and businesses that rely on product NCMY05 (B)	0 (0%)	2 (5.7%)	0 (0%)	7 (20%)	9 (25.7%)	5 (14.3%)	12 (34.3%)	5.46	1.4	(6)
National macroeconomic NCMY02	1 (2.9%)	2 (5.7%)	1 (2.9%)	8 (22.9%)	8 (22.9%)	9 (25.7%)	6 (17.1%)	5	1.5	(5)
Government expenses "Overfunding" NCMY07	1 (2.9%)	1 (2.9%)	4 (11.4%)	10 (28.6%)	6 (17.1%)	8 (22.9%)	5 (14.3%)	4.8	1.5	(5)
Criticality of the product to survive NCMY08	1 (2.9%)	1 (2.9%)	2 (5.7%)	4 (11.4%)	2 (5.7%)	7 (20%)	18 (51.4%)	5.8	1.7	(5)
Societal attitude NCMY09	3 (8.6%)	4 (11.4%)	4 (11.4%)	11 (31.4%)	5 (14.3%)	5 (14.3%)	3 (8.6%)	4.09	1.7	(4)
Advancement of national technology and innovation NCMY14	3 (8.6%)	2 (5.7%)	2 (5.7%)	10 (28.6%)	3 (8.6%)	8 (22.9%)	7 (20%)	4.7	1.9	(5)

5.1.3 Hypotheses Result

Pearson correlation coefficient measures the linear relationship between two variables in a range of -1 to 1whereas -1 indicates a perfect negative relationship, 0 means there is no relationship at all, and +1 indicates a perfect positive relationship (Schober & Schwarte, 2018). As of this research, there is a positive significant relationship (.297) between the model's dimensions of supply risk and the PEST factors in terms of identifying the criticality level of intermediate and final products nationally. As shown in Table 39, the significant which often denote as sig. or p-value < .001, which means that the null hypothesis is rejected, and the alternative hypothesis is accepted. Due to the statistically significant relationships between the study's factors, further statistical analysis was considered.

Table 39: Pearson Correlations Result

Correlations

		PEST	Supply Risk
PEST	**Pearson Correlation**	1	.297**
	Sig. (2-tailed)		<.001
	N	152	152
Supply Risk	**Pearson Correlation**	.297**	1
	Sig. (2-tailed)	<.001	
	N	152	152

****. Correlation is significant at the 0.01 level (2-tailed).**

5.1.4 Instrument Reliability

In order to ensure the quality of the instrument as well as the statistical outcomes of the study, it is essential to test its reliability before proceeding to additional statistical analysis. Although the first reliability test indicated that the reliability of the instrument was acceptable (0.857) for the 37 variables, the number of valid cases was 43, and the number of missing cases was 109, as shown in Table 40.

Table 40: Case Processing Summary (1)

Case Processing Summary

		N	%
Cases	Valid	43	28.3
	Excluded	109	71.7
	Total	152	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.857	37

This result was due to the fact that the questions asking the experts about their satisfaction level with the availability and implementation of policies and procedures have been taken to manage the recyclability of the products being tested. Semiconductors are considered to be a recyclable products, whereas gasoline and insulin are not. Testing the reliability of the instrument after removing these two questions gave the results shown in Table 41. These indicate acceptable reliability.

Table 41: Case Processing Summary (2)

Case Processing Summary

		N	%
Cases	Valid	118	77.6
	Excluded	34	22.4
	Total	152	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.830	35

5.1.5 Factors Validity and Reduction

Assessing the validity of the measurement variables is important for how accurate and reliable the study's findings are. To obtain this, the study implanted two statistical key techniques: item-total correlation and factor analysis. Utilizing item-total correlation, the researcher evaluated the extent to which each item within the measurement instrument corresponds with the overall structure it aims to measure. This allows the researcher to identify items that may be in need of refinement or removal for a more substantial construct validity. Furthermore, factor analysis delivers an extensive statistical approach for uncovering the underlying structure of the variables, clarifying their connections to one another, and confirming the dimensions they represent. With the help of these analytical tools, the researcher both validates the results and ensures that the measurement variables are precise, leading to reliable outcomes. This section provides an integral foundation for the following analyses and conclusions of the study.

I Item-Total Correlation (ITC)

This research used the item-total correlation and factor analysis to validate and extract the final model's variables, with the aim of measuring the criticality level of intermediate and final products on a national basis. Table 42 shows the result of the item-total correlation followed by the factor analysis results.

Table 42: Item-Total Correlation Result

#	Variable	V. Code	Item-Total Correlation
	Supply risk factor		
1	Availability of required raw materials and natural resources	NCMX01	.155
2	Availability of feasible alternatives	NCMX02	.270
3	Availability of qualified personnel	NCMX03	.369
4	Availability of local producer	NCMX05 (A)	.376
5	Availability of investors	NCMX06	.474
6	Self-sufficiency	NCMX04	.537
7	Availability of scientific research centers	NCMX08	.420
8	Logistic challenges	NCMX14	.488
9	Forecasting accuracy ratio	NCMX16	.561
10	Consumer behavior “Consumption behavior”	NCMX21 (A)	.456
11	Consumer behavior “Aval. of policies and procedures to manage the consumption behavior”	NCMX21 (B)	.514
12	Consumer behavior “implementation of policies and procedures to manage the consumption behavior”	NCMX21 (C)	.458
13	Complexity ratio “Easiness to Produce”	NCMX18 (A)	-.104
14	Complexity ratio “Easiness to Store”	NCMX18 (B)	.003
15	Operational cost	NCMX24	.202
16	Aval. of global supplier	NCMX05 (B)	.530
17	External dependence	NCMX07	.225
18	Export capacity	NCMX27	.488
19	Trade agreement	NCMX29	.429
20	Supply vulnerable	NCMX12	.127
21	Supplier's country stability	NCMX13	.298
22	Policies and procedures intervention	NCMX15	.241
23	Market condition and structure	NCMX26	.119
24	Global market competition	NCMX23	.249

Table 42 (continued)

PEST factors			
1	Nation's stability and security	NCMY01	.636
2	Demand	NCMY04	.502
3	Price stability	NCMY03	.491
4	Investment	NCMY06	.601
5	Criticality of the product "Public projects/services that rely on product"	NCMY05 (A)	.686
6	Criticality of the product "Local industries and businesses that rely on product"	NCMY05 (B)	.702
7	National macroeconomic	NCMY02	.433
8	Government expenses "Overfunding"	NCMY07	.633
9	Criticality of the product's survival	NCMY08	.566
10	Society's attitude	NCMY09	.486
11	Advancement of national technology and innovation	NCMY14	.502

According to the item-total correlations, the extracted variables are presented in Table 43, which are above (.30).

Table 43: Final Measurement Variables Based on (Item-total Correlation)

#	Variable Name	V. Code	Mean	SD	Item-total correlation
1	Availability ratio of (local/global) suppliers	NCMX05 (A)	3.01	1.85	.376
		NCMX05 (B)	5.00	1.53	.530
2	Availability ratio of investors	NCMX06	3.81	2.04	.474
3	Self-sufficiency	NCMX04	4.15	1.99	.537
4	The availability of scientific research centers	NCMX08	3.21	1.74	.420
5	Logistic challenges	NCMX14	4.66	1.97	.488

Table 43 (continued)

6	Forecasting accuracy ratio	NCMX16	4.14	1.74	.561
7	Consumer behavior	NCMX21 (A)	3.49	1.58	.456
		NCMX21 (B)	3.49	1.73	.514
		NCMX21 (C)	3.33	1.69	.458
8	Export capacity	NCMX27	5.05	1.41	.488
9	Trade agreements	NCMX29	5.01	1.31	.429
10	Availability of qualified personnel	NCMX03	3.63	1.85	.369
	PEST factors				
1	National stability and security	NCMY01	4.24	1.87	.636
2	Demand	NCMY04	5.57	1.58	.502
3	Price stability	NCMY03	5.51	1.75	.491
4	Investment	NCMY06	4.98	1.67	.589
5	Criticality of the product	NCMY05 (A)	4.87	1.73	.626
		NCMY05 (B)	5.12	1.57	.702
6	National macroeconomics	NCMY02	3.94	1.77	.433
7	Government expenses “Overfunding”	NCMY07	4.43	1.82	.633
8	Criticality of the product’s survival	NCMY08	4.45	2.03	.566
9	Society’s attitude	NCMY09	4.39	1.77	.486
10	Advancement of national technology and innovation	NCMY14	4.21	2.03	.502

The reliability of the instrument based on the item-total correlation was (0.844) shows an improvement as well when compared to the extraction analysis.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.844	.848	25

Figure 28:Instrument Reliability (Item-total correlation)

II Factor Analysis (FA)

Before applying factor analysis, two statistical tests are needed to assess the possibility of using factor analysis: the Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy and Bartlett's Test of Sphericity. The KMO result (0.698) indicates that the data are suitable for factor analysis (Shrestha, 2021). On the other hand, Bartlett's Test of Sphericity tests the strength of the relationships between variables. It is used to test the null hypothesis, which is supposed to be close to zero – as long as the result does not exceed the value of 0.05. As shown in Table 44, the significant value (0.001) is close enough to zero to confirm the suitability of the data for factor analysis (Shrestha, 2021).

Table 44: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.698
Bartlett's Test of Sphericity	Approx. Chi-Square	2110.355
	Df	595
	Sig.	<.001

The data were considered for further analysis based on KMO and Bartlett's Test of Sphericity: the Kaiser's criterion (eigenvalues) test and the Scree test (see Table 45).

Table 45: Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.997	17.136	17.136	5.997	17.136	17.136	3.634	10.383	10.383
2	4.760	13.599	30.734	4.760	13.599	30.734	3.613	10.323	20.706
3	3.501	10.004	40.738	3.501	10.004	40.738	3.556	10.160	30.866
4	2.614	7.468	48.207	2.614	7.468	48.207	3.244	9.269	40.136

Table 45 (continued)

5	2.053	5.866	54.073	2.053	5.866	54.073	2.638	7.536	47.672
6	1.489	4.254	58.327	1.489	4.254	58.327	2.237	6.392	54.063
7	1.307	3.734	62.061	1.307	3.734	62.061	2.018	5.766	59.829
8	1.157	3.307	65.368	1.157	3.307	65.368	1.533	4.379	64.208
9	1.064	3.040	68.408	1.064	3.040	68.408	1.470	4.199	68.408
10	.977	2.791	71.199						
11	.907	2.591	73.790						
12	.798	2.280	76.071						
13	.757	2.164	78.235						
14	.720	2.057	80.291						
15	.634	1.812	82.104						
16	.574	1.640	83.744						
17	.562	1.606	85.350						
18	.526	1.504	86.854						
19	.491	1.402	88.255						
20	.464	1.327	89.582						
21	.415	1.187	90.769						
22	.395	1.128	91.897						
23	.353	1.008	92.905						
24	.339	.968	93.873						
25	.301	.861	94.734						
26	.286	.818	95.552						
27	.250	.715	96.267						
28	.231	.659	96.926						
29	.224	.640	97.567						
30	.196	.561	98.128						

Table 45 (continued)

31	.183	.524	98.651						
32	.141	.404	99.056						
33	.131	.375	99.431						
34	.119	.341	99.772						
35	.080	.228	100.000						

Extraction Method: Principal Component Analysis.

As shown in Table 45, the eigenvalues for the first nine components are greater than 1, which is effective enough to represent the remaining 35 variables. The values of components 1–9 were: 5.997; 4.760; 3.501; 2.614; 2.053; 1.489; 1.307; 1.157>1; and 1.064, respectively. These were all greater than 1, and they explained 68.408 of the variances with other variables. The values of the remaining components were less than 1. The Scree plot graph was drawn by comparing the number of components and eigenvalues. It shows that the first nine eigenvalues' components were greater than 1, whereas the remaining 35 account for a tiny proportion of the variability.

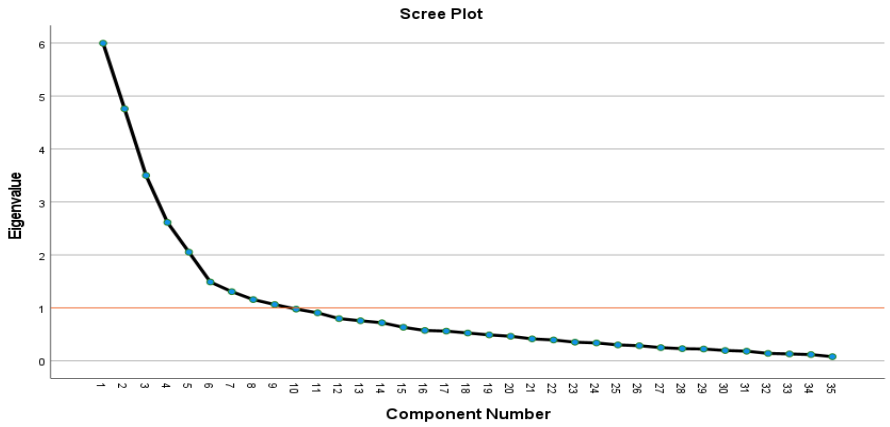

Figure 29: Scree Plot Result

The component matrix in Table 46 shows the loading factor, which illustrates the extent to which each variable is explained by the component. The greater the value of correlation, the more the variables are explained by the component. The possible range of correlation values is -1 to +1. To suppress the loading factors, any correlation less than 0.30 were excluded from making the output clearer and easier to read (Tavakol & Wetzel, 2020). It appears that some variables, such as price stability, measure more than one component (1, 2, 3, 4 and 9); however, component 1 has a higher positive correlation value, which is explained more by the first component, unlike component 9. Therefore, the rotation was considered a part of reducing the load of the factors and redistributing them on the rotated component matrix, as presented in Table 47.

Table 46: Component Matrix

	Component								
	1	2	3	4	5	6	7	8	9
Aval. of global supplier	.618								-.351
Local industries and businesses that rely on product	.609	.405			-.338				
Satisfaction of the accuracy of available data	.594	-.515							
Aval. of policies and procedures to manage the consumption behavior	.590	-.460		-.316			.315		
Satisfaction of overall logistic services	.571	-.441							
Aval. of strategic reserves	.552	-.460							
Demand	.550	.304	.319						
Satisfaction with the implementation of policies and procedures to manage the consumption behavior	.545	-.455		-.388					
Satisfaction of the consumption behavior	.515	-.373					.370		
Public projects/services that rely on product	.510	.440			-.362				
Aval. of investors	.502	-.383	-.396						
ROI	.497	.345							
Export capacity	.486	-.313	.335		.344				
Trade agreement	.463	-.379			.313				
Societal attitude	.400			.303	-.347		-.337		
Price stability	.385	.323	.323	.312					-.338

Table 46 (continued)

Advancement of national technology and innovation		.632				.351			
Government expenses		.624		-.434					
Nation's stability and security	.470	.553						.311	
National macroeconomic		.466		-.453					
Easiness to Produce			.695						
Aval. of qualified personnel	.428		-.667						
Aval. of local producer	.451		-.641						
External dependence			.622						
Aval. of scientific research centers	.454		-.592						
Aval. of raw materials			-.585	.345					
Aval. of feasible alternatives				.656					
Criticality of the product to survive		.570		-.572					
Market condition		.410		.470					
Supply vulnerable		.343		.468		.336	.313		
Supplier's country stability			.358		.647				
Policies and procedures intervention		.334		.345	.369			-.316	
Easiness to Store		.309			.338				
Operational cost						-.430		.638	
Global competition	.335	.323							-.598

Extraction Method: Principal Component Analysis.

a. 9 components extracted.

Table 47: Rotated Component Matrix

	Component								
	1	2	3	4	5	6	7	8	9
Public projects/services that rely on product	.784								
Societal attitude	.720								
Local industries and businesses that rely on product	.704								
ROI	.690								
Nation's stability and security	.641								.415
Demand	.487						.358		
Aval. of qualified personnel		.778							
Aval. of local producer		.738							

Table 47 (continued)

Aval. of scientific research centers		.719					.305		
Aval. of raw materials		.686							
Easiness to Produce		-.671							
Aval. of investors		.550					.427		
Aval. of policies and procedures to manage the consumption behavior			.882						
Satisfaction with the implementation of policies and procedures to manage the consumption behavior			.854						
Satisfaction of the consumption behavior			.770						
Satisfaction of the accuracy of available data			.720				.456		
Satisfaction of overall logistic services			.583				.558		
Criticality of the product to survive				.876					
Government expenses				.762					
National macroeconomic				.719					
Aval. of feasible alternatives		.427		-.567					
Advancement of national technology and innovation				.544			-.459		
Easiness to Store				.418		.334			.307
Trade agreement			.374		.787				
Export capacity					.763				
Supplier's country stability					.623	.487			
Aval. of global supplier					.580			.377	
External dependence		-.361			.505	.313			.415
Supply vulnerable	.304					.767			
Policies and procedures intervention						.713			
Market condition						.545		.398	
Aval. of strategic reserves		.383			.319		.630		
Global competition								.780	
Price stability	.506							.576	
Operational cost									.780

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 13 iterations.

With regard to the study's factors and objectives, the component was reduced from 9 components to 2. As shown in Tables 48 and 49, after removing all weak and negative values, five variables were considered component 2, which consists of all the PEST factor variables. These variables are the availability of qualified personnel, supply vulnerability, global competition, policies and procedures interventions, and market conditions. Following the object of this study, they were removed, which improved the correlation value and resulted in the final measurement variables.

Table 48: Rotated Component Matrix (1)

	Component 1	2
Sati. of the accuracy of available data	.797	
Ava. of policies and procedures to manage the consumption behavior	.770	
Sati. with the implementation of policies and procedures to manage the consumption behavior	.740	
Sati. of overall logistic services	.727	
Ava. of strategic reserves	.704	
Sati. of the consumption behavior	.656	
Ava. of investors	.635	
Ava. of global supplier	.591	
Trade agreement	.575	
Export capacity	.548	
Ava. of local producer	.412	
Ava. of scientific research centers	.384	
Nation's stability and security		.725
Local industries and businesses that rely on product		.701
Public projects/services that rely on product		.685
Advancement of national technology and innovation		.603
Government expenses		.596

Table 49: Rotated Component Matrix (2)

	Component 1	2
Sati. of the accuracy of available data	.808	
Ava. of policies and procedures to manage the consumption behavior	.769	
Sati. of overall logistic services	.741	
Sati. with the implementation of policies and procedures to manage the consumption behavior	.728	
Ava. of strategic reserves	.702	
Sati. of the consumption behavior	.651	
Ava. of investors	.610	
Ava. of global supplier	.593	
Trade agreement	.585	
Export capacity	.569	
Ava. of local producer	.366	
Ava. of scientific research centers	.334	

ROI		.590
Demand		.571
Criticality of the product to survive		.570
National macroeconomic		.530
Price stability		.507
Societal attitude		.497
Global competition		.445
Policies and procedures intervention		.421
Market condition		.419
Supply vulnerable		.391
Ava. of qualified personnel		.335

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.a
a. Rotation converged in 3 iterations.

Local industries and businesses that rely on product		.737
Nation's stability and security		.730
Public projects/services that rely on product		.718
Government expenses		.656
Criticality of the product to survive		.636
Advancement of national technology and innovation		.608
ROI		.599
National macroeconomic		.593
Demand		.567
Societal attitude		.511
Price stability		.454

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a
a. Rotation converged in 3 iterations.

As it can be seen in Table 49, component 1 consists of all the supply risk variables, and Component 2 consists of all the PEST variables. By reducing the component from 9 to 2, twelve variables were excluded due to the weakness of their correlation: the availability of raw materials, the availability of feasible alternatives, the availability of qualified personnel, external dependency, ease of production and storage, operational costs, and supplier country stability, supply vulnerability, global competition, policies and procedures interventions, and market conditions. Table 50 represents the final variables based on the factor analysis result for the supply risk and PEST factors.

Table 50: Final Measurement Variables Based on (Factor Analysis)

#	Variable Name	V. Code	Commun ality after extraction	Mean	SD	Factor loading
		Component 1: Supply Risk Factor				
1	Availability ratio of (local/global) suppliers	NCMX05 (A)	.190	4.99	1.82	.366
		NCMX05 (B)	.398	3.00	1.53	.593
2	Availability ratio of investors	NCMX06	.373	4.19	2.04	.610
3	Self-sufficiency	NCMX04	.494	3.84	1.99	.702
4	The availability of scientific research centers	NCMX08	.170	4.78	1.74	.334
5	Logistic challenges	NCMX14	.550	3.33	1.97	.741
6	Forecasting accuracy ratio	NCMX16	.654	3.86	1.74	.808
7	Consumer behavior	NCMX21 (A)	.426	4.50	1.58	.651
		NCMX21 (B)	.592	4.50	1.73	.769
		NCMX21 (C)	.531	4.66	1.68	.728
8	Export capacity	NCMX27	.324	2.94	1.41	.569
9	Trade agreements	NCMX29	.342	2.99	1.31	.585
		Component 2: PEST factors				
1	National stability and security	NCMY01	.534	4.22	1.86	.730
2	Demand	NCMY04	.386	5.64	1.48	.567
3	Price stability	NCMY03	.223	5.57	1.65	.454
4	Investment	NCMY06	.394	4.90	1.58	.599
5	Criticality of the product	NCMY05 (A)	.534	4.69	1.71	.718
		NCMY05 (B)	.599	5.04	1.53	.737
6	National macroeconomics	NCMY02	.357	3.88	1.77	.593
7	Government expenses “Overfunding”	NCMY07	.493	4.21	1.78	.656
8	Criticality of the product’s survival	NCMY08	.430	4.36	1.99	.636
9	Society’s attitude	NCMY09	.280	4.30	1.78	.511
10	Advancement of national technology and innovation	NCMY14	.439	4.09	2.09	.608

The reliability of the instrument based on the factor analysis outcome (0.829) shows an acceptable value almost the same when compared to the extraction analysis. Based on this, the multidimensional scale model was run, which led to the final study result, as shown in Figure 30.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.829	.833	22

Figure 30: Instrument Reliability (Factor analysis)

5.1.6 Multidimensional Scaling (MDS)

Based on the result of utilizing two different statistical methods to determine the most applicable variable to apply for evaluating the criticality level of rice, gasoline, semiconductors, and insulin in Saudi Arabia are given in the following Figure 31, which interpret and visualize experts' opinion into the purchasing portfolio matrix using the multidimensional scale technique. It uses the total mean of final variables for each product that was extracted by factor analysis, as shown in Table 50.

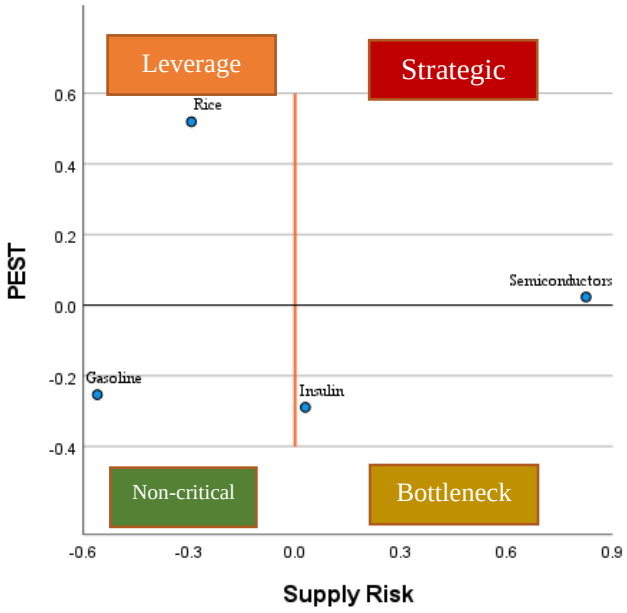

Figure 31: Products Positions

Table 51: Dimension Means (MDS input)

Dimensions	Sub-cases			
	Rice	Gasoline	Semiconductors	Insulin
	Mean	Mean	Mean	Mean
Supply risk factor	3.45	3.16	4.80	3.86
PEST factors	4.07	5.02	4.62	5.01

Although rice is considered to be a strategic product in Saudi Arabia, according to the concept of the purchasing portfolio, it has been categorized under the leverage quadrant. As for gasoline, the result is unexpected in the largest oil-producer country, listed under the non-critical quadrant. With regard to the lifesaver, insulin, it was expected to be a strategic product; however, according to the purchasing portfolio, it has been classified as a bottleneck quadrant close to the non-critical quadrant. Finally, semiconductors in Saudi Arabia are classified as a strategic product with the same level of criticality as in the United States of America.

5.2 Result Evaluation and Validation

As a final step of analysing the data, the result was evaluated and validated in this stage. At this point, four experts were involved. The questionnaire followed similar procedures to those employed by Arantes et al. (2022) and Padhi et al. (2012) as a validation step. First, the model and meaning of each quadrant were explained to the experts. Then, the final result was presented. After that, they were asked whether if they agreed or disagreed with the position of each product in the matrix, with a justification. If they did not agree, they were asked to reposition the product (see Appendix C).

With regard to the study's outcome, four types of products were tested based on the principle of a purchasing portfolio. It consisted of four quadrants, as illustrated earlier in section 2.4: the strategic quadrant, leverage quadrant, bottleneck quadrant, and non-critical quadrant. Each

of these had its own guidance and strategies to manage the object being tested, which is the ultimate purpose of the purchasing portfolio model.

(RQ2.1) The leverage quadrant applies when the level of PEST impact is high and the level of supply risk is low. On an organisational level, this is the most favourable quadrant, as the risk in the supply flow is low due to either the local availability of the product or the number of available suppliers around the world (Farmer & Weele, 1995; C. Gelderman & Weele, 2005). This low risk gives the buyer an opportunity to exploit the market, which is positively reflected in the organisation's income/profit. In this study, the concern is more about stabilising the PEST factors. Rice, as illustrated previously, is one of the most demanded products in Saudi Arabia, but at the same time, it is extremely difficult to farm it locally due to the nature of the land. Only a small part of Saudi Arabia produces what is called Hassawi rice, but not enough to meet even local demand (Al-Turki & Basahi, 2015). This rice is considered to be one of the healthiest types of rice as it reduces the risk of type 2 diabetes (Al-Mssallem et al., 2011; Al-Turki & Basahi, 2015). It was expected that the Saudi Agriculture Ministry would classify it as belonging to the strategic quadrant, but actually, it is positioned in the leverage quadrant. This raised questions about the reasoning behind this. An interview was carried out with an expert in the field, who explained the key actions being taken by the government of Saudi Arabia in terms of securing rice. After the researcher had explained the model and the purpose of the study, the participant answered, "*I agree with the result … indeed, we have a strong food system. Maybe you remember during COVID-19, we had totally no issues with any type of food, especially rice since this is the case … Our government has a strong relationship with several big rice exporters like India, Pakistan … and recently Thailand, which smooths out the process of exporting … You remember last year when the government of India banned the exporting of rice to control its local market, they excluded*

Saudi Arabia from the list … so it's kind of paving the way for investors … just go and invest over there to secure our market … Not only this, the government supports these agencies, in particular rice agents. In fact, it goes beyond that, and now our investors are purchasing and owning farmlands in different parts of the world … The government implemented different policies and programmes to prevent food wastage … we can produce rice, here look at Al-Hassa … I know it might be costly for us, but we have the capability … Do more research, try to solve this issue, look at other parts of the kingdom that are similar to Al-Hassa and try to farm rice there … Indeed, one of the successful experiences we have in Saudi Arabia is fish farming, we are now supplying other big markets like China … try to promote other alternative products that might be healthier," AM56. Four key strategies can be extracted from this conversation: managing the consumption behaviour related to critical products; the role of local investors in securing the availability of critical products; the role of government in securing critical products by supporting agents (subsidised products); and the role of R&D. As we can see, in Saudi Arabia rice is regarded as a scarce product because it is very difficult to locally produce, and the nation relies heavily on external suppliers. With the use of some of these strategies, the government, according to the purchasing portfolio, was able to move rice from the strategic to the leverage quadrant. By implementing other strategies, such as those suggested by AM56, the government might even be able to move rice towards the non-critical quadrant.

(RQ2.2) The non-critical quadrant applies when the level of both dimensions is low. Although the product is critical, it is abundant in the local market. Therefore, it requires minimal management compared to the strategic, bottleneck, and leverage quadrants. On an organisational level, standardising the purchasing of these types of products is recommended (Farmer & Weele, 1995; C. Gelderman & Weele, 2005). In this study, gasoline is classified as a non-critical product

because Saudi Arabia is the world's largest oil producer (M. A. Al-Sahlawi, 1997; Alyousef & Aljarrah, 2012; EIA, 2021a; Mikayilov, Joutz, & Hasanov, 2019). That does not mean that gasoline is not important, but due to the abundance of oil in Saudi Arabia and the use of gasoline, it is regarded as a non-critical product. To verify this, the question was directed to the economics professor, SF03. At the beginning, he was surprised that gasoline was classified as a non-critical product; however, after explaining the principle of the purchasing portfolio and how it is applied and used, he answered as follows: "… *I would definitely agree after maybe ten years from now, as we are in a process of shifting as you can see … we start to have other forms of public transportation with good facilities. Go to Makkah or Riyadh, and you will be surprised by the public transportation over there … you might have heard about the Lucid factory, where if I'm not wrong, their target is to produce more than one hundred thousand electric cars in a year … not sure about the number … but for now I think it's too early to leave gasoline or to list it as a non-critical product … due to the abundance of oil, I think it should be here in the strategic quadrant or at least in the leverage quadrant since we don't have an issue so far with supply …for now*." According to this informative interview, the abundance and availability of other feasible alternatives are key features of the non-critical quadrant. In fact, this proves the credibility of the purchasing portfolio when applying it on a national level, regardless of the type of product being tested. As recommended by Kraljic (1983), it is crucial to ensure that multiple approved suppliers can secure the supply flow.

(RQ2.3) The strategic quadrant applies when the level of PEST and the supply risk impact is high. Any products classified inside this quadrant usually have a very limited source of supply, and at the same time, the absence of the product would have a high level of impact on politics, the economy, the sociocultural aspect of life, or technology. Often, the products are

sourced globally and have a high level of supplier involvement (Farmer & Weele, 1995; C. Gelderman & Weele, 2005). In this study, semiconductors are classified as a strategic product in Saudi Arabia. MM61 confirmed this: "*Of course, this is where it is supposed to be … if you look at our Vision 2030, we started getting rid of oil, and we have become one of the industrial countries … most if not all industries rely on semiconductors so you really need them … here in Saudi Arabia, the fact is that we have just started to recognise the importance of localising this industry, which we have taken many steps towards*". However, to manage a product that is classified as strategic, Kraljic (1983) and Lambert et al. (2022) emphasised the importance of building a strong and long-term relationship with the suppliers. A recent Qatar-German long-term (15 years) natural gas contract is a good example of this (Lambert et al., 2022). A buying consortium is another applicable solution for managing and securing critical products. In 2010, the Korean Public Procurement Service took the initiative to establish a buying consortium that combined the big three nations, Korea, China, and Japan – the largest raw material consumers. Although they are considered to be competitors on an organisational level, on a national level, cooperation achieves many cost savings or increases buying power (Choi, 2010). During the interview, the expert emphasised the importance of localising the semiconductor industry, and the participant wondered, "*Why not? … we have the capability and opportunity now, and it might be difficult later*" (MM61). That aligns with the call to re-localise the semiconductor industry in the United States of America (The White House, 2021a).

(RQ2.4) The bottleneck quadrant applies when the level of supply risk is high, and the PEST impact is low. The criticality of the product occurs due to the limited availability of suppliers in the market. They are essential products, require a high level of attention and may involve long-term supplier relationships to ensure supply continuity (Farmer & Weele, 1995; C. Gelderman &

Weele, 2005). In the current study, insulin is positioned within the bottleneck quadrant. In this quadrant, the supplier dominates the market and has more power than the buyer; therefore, a diversified strategy is recommended (Kraljic, 1983). This means buyers should diversify their supply by sourcing from multiple suppliers to mitigate risk and avoid any potential interruption. In terms of the position of insulin in Saudi Arabia, three important government initiatives, "strategies", were noted: localising the industry with a high level of production capacity that satisfies the regional market, a public health campaign to increase the awareness of diabetes in terms of its symptoms and risk factors; and encouraging individuals to adopt a healthier lifestyle and behaviours as preventative measures against the disease. This aligns with the Saudi Vision 2030 government initiatives (Saudi Vision 2030, 2017). SM08 believed this had had a positive impact by reducing the number of people with diabetes in Saudi Arabia. During the interview, the expert justified the reasons behind the current position in Saudi Arabia: "*I believe yes… it might be a consequence of localising the industry… you might have heard about Saudi Bio, the insulin factory… there are some operational issues, but still, we are on our way … until now, we relied on external suppliers, but not like before ... I think with the growing percentage, it supposes to be in the middle of the chart, a little bit upper between leverage and strategic quadrants ….*" Another point that stuck with me was when the participant talked about the government initiatives and how the health department (ministry) dealt with diabetes. The participant said, *"… a lot of effort and strategies have been taken to reduce this percentage … educating society, which I believe is the most important factor … their lifestyle and behaviour will be changed …now we have open areas for walking equipped with exercise equipment… go and see a lot of people start using these facilities, not like before … not only diabetes … I believe all these factors will contribute positively to have a healthier society.*"

Chapter 6: Research Discussion and Conclusions

6.1 Introduction

This chapter concludes the investigation of this study, which aims to develop a model to manage the national strategic reserves for critical intermediate and final products. This study is guided by research questions, which facilitated the analysis of the study findings presented in chapters four and five. This chapter discusses the research findings, contributions and limitations and provides recommendations for future research opportunities.

6.2 Findings Discussion (Strategic Recommendations)

This research is built on a theoretical base by providing an understanding of the relevant theories related to critical intermediate and final products. The study was constructed by the Resource Dependency Theory and the Portfolio Theory – purchasing model. It then reviewed the literature on studies related to the national strategic reserve and criticality studies. The dimensions of the model were identified by referring to these studies. Five main factors shaped the criticality level of intermediate and final products on a national basis: supply risk (the casual factor) and PEST factors (the impacted factors). This was confirmed by carrying out qualitative research with twenty-three experts to validate and confirm the measurement variables in order to answer the first research question, RQ1 "*What are the most significant variables that determine the level of importance of critical intermediate and final products at the national level in Saudi Arabia*?".

Based on these variables, the instrument of the study was developed. There were two reasons for the use of this instrument. One was to confirm the measurement variables quantitatively; 19 variables were confirmed using the factor analysis technique. This was used to

support the qualitative result, which answered the first research question. Second, the data were used to evaluate the criticality level of intermediate and final products on a scale of 1–7. These data were interpreted and visualized by the MDS technique to answer the following sub-research questions: RQ2.1 "*The Ministry of Environment Water and Agriculture in Saudi Arabia listed rice as one of the strategic products; how likely is this to be true, based on the purchasing portfolio principles?"* the answer to this question classified rice as a leverage product; RQ2.2 *"Based on the purchasing portfolio principle, is gasoline considered to be a strategic product in the country with the largest crude oil producer, Saudi Arabia?*" the answer was that gasoline is a non-critical product in Saudi Arabia; RQ2.3 *"The United States of America and China are competing on semiconductors products. Based on the purchasing portfolio principles, what is the criticality level of semiconductors in Saudi Arabia?"*, to which the answer was that semiconductors are a strategic product; and RQ2.4 *"Insulin is a life saver for people with diabetes. Based on the purchasing portfolio viewpoint, what is the status of insulin in Saudi Arabia?*" and the result showed that insulin is categorized as bottleneck product in Saudi Arabia.

As a final pillar of purchasing portfolio studies, a strategic recommendation that answers the third sub-research question that concludes the study's investigation, RQ3 "*What are the key strategic recommendations that could be considered by policymakers to manage critical intermediate and final products on a national level in Saudi Arabia?*" is proposed in this section. To manage and secure a critical product, a number of strategic solutions were recommended. Most of these recommendations were directed at organisations. The scholars proposed two different methods for dealing with scarce products: bridging and buffering. Bridging describes the extent to which the organisation depends on external suppliers adopting a number of activities to satisfy and

secure their needs (C. Gelderman, 2022). In the context of the Resource Dependency Theory (Pfeffer & Salancik, 1978), there are five different bridging activities:

1. **Merger and acquisitions** is a strategy that aims to manage and gain access to scarce or critical products as it can help acquire a new resource such as technology or a particular product. A great example here is the historical deal when the Chinese company "Shanghai International Holdings Ltd" acquired the largest pork farm "Smithfield Foods, Inc." in the USA (Gale et al., 2012; Kemp, 2013). This gave the Chinese government a great chance to control and secure their pork supply chain.
2. **The joint venture** allows partners to share their resources, experience, knowledge, etc., depending on the agreement between the partners. This is one way of mitigating risk and securing the supply.
3. **Board of directors** which in the context of the Resource Dependence Theory refers to the in-charge management making links between the organisation and its external environment. It aims to identify and manage the risks associated with the organisation's dependence on external resources and to ensure the availability of the required resources without affecting the organisation's activities or its objectives.
4. **Political action** which refers to the organisation's efforts to persuade the government to legalise policies and procedures to serve their own interests and gain a more favourable environment for their business, such as reducing the barriers to accessing a critical resource. However, in order to manage critical products, governments tend to simplify and smooth the process of obtaining them. See, for example, MEWA (2022) and Mousa and Ford (2021).
5. **Executive succession** mainly refers to human resources and the "organisation's leadership", as they are considered critical resources and valuable assets for leading the organisation due to

their expertise, knowledge, and skills. Therefore, it is crucial to ensure the smooth process of executive turnover, as leaders drive the success of an organisation.

The adoption of these bridging strategies will contribute to reducing organisations' dependence and, at the same time, increase their power in the face of uncertainty (C. Gelderman, 2022). On the other hand, the buffer strategy aims to enhance the power of an organisation and reduce its uncertainty by providing a backup source in case the primary source fails or becomes unavailable, for example, by holding strategic reserves (C. Gelderman, 2022; Pfeffer & Salancik, 1978). Most of these strategies are applicable at the national level, as has been identified and demonstrated by the product positioning as the result of this study.

With regard to securing access to critical raw materials, a recent report published by Calvino (2022) summarised the strategic action that has been taken by eight countries (Australia, Canada, China, the European Union, Indonesia, Japan, the United Kingdom, and the United States of America) to mitigate the risks that might hinder access to required raw materials. The Australian government focused on supporting investment and promoting R&D through the critical minerals facility, which aims to assist Australian companies with producing and exporting critical minerals (Export Finance Australia, 2023), and the critical minerals development programme, which aims to accelerate the development and processing of critical mineral resources (CMDP, 2023). In 2022, the Canadian government spent approximately USD 3 billion on strengthening its critical minerals strategy, which includes increased infrastructure investment and financial support for exploration and R&D projects. In addition, the Canadian government introduced a concessions tax for eligible investments (CA Government, 2022). Since the 1980s, the Chinese government has recognised the strategic potential of critical minerals; therefore, several actions have been implemented to ensure the availability of required minerals for as long as possible. These included encouraging

exploration, regulating and reducing production, securing a mineral supply to strategic emerging industries, and developing a circular economy in the mining industry. The European Union has implemented different programmes with the aim of mitigating the risk of supply chain disruption for critical raw materials. It encourages investment in the field of critical raw materials by deploying the European Investment Bank to finance projects related to these materials; it has created the European Raw Materials Alliance, a public-private partnership (PPP) that aims to identify, coordinate and facilitate investment in critical materials; and it promotes R&D, aiming to increase the recyclability of critical raw materials, develop new substitute materials, and develop new mining technology. Finally, it has limited foreign investment in strategic sectors of the economy, including critical raw materials industries. This is unlike the Indonesian government, which adopted a policy to attract foreign investors with the conditions that the operations were localised and hired local labour. The Japanese government took a similar path. They developed a new recyclable and recovery technology to take advantage of discarded products, and they explored and increased the public strategic reserve for all critical raw materials (Calvino, 2022).

With regard to investment in critical raw materials, the Japanese government tends to support Japanese companies in local and global projects related to these materials. At the same time, foreign investors in Japanese critical raw materials industries are required to obtain government permission to access these companies (Calvino, 2022). In 2022, the United Kingdom launched its critical minerals strategy, which is founded on three key elements to secure the availability of critical raw materials. These are to carry out more R&D in order to increase local production; to become more efficient in using critical raw materials by promoting different supportive programmes to fund projects related to critical raw materials industries, such as UK Research and Innovation (UKRI, 2023); and controlling foreign investments in these industries by

imposing the National Security and Investment Act, enforced in January 2022 (UK Gov., 2023). The latter gives the UK government the right to block forging countries from investing on national security grounds. Finally, in the United States of America, different actions have been taken to manage and secure the availability of critical materials through a number of policies and procedures that aim to increase the robustness of the country's local supply chain and reduce its dependency on external suppliers (Calvino, 2022). These consist of diversifying the supply, developing substitutes, improving reusing and recycling, and investing more in R&D (US Department of Energy, 2018). In terms of forging investment, two recently issued executive orders, 13953 (The White House, 2021a) and 14017 (The White House, 2021b), aim to prevent adversaries from investing in strategic economic activities. To sum up, four main directions can be observed from Calvino's report: increasing the domestic resources' extraction and processing capabilities; increasing the possibilities for recycling by investing in innovation and exploring a circular economy; securing national production and building a strategic reserve; and finally, managing exports and investment abroad (Calvino, 2022).

Several successful strategies have been documented regarding the results of this study. One that moved rice from the strategic quadrant to the leverage quadrant is the merger and acquisitions strategy, represented by Saudi investors owning farmland in different countries. In addition, localising the industry, as in the case of insulin in Saudi Arabia, reduces dependency on external suppliers, which is part of a joint venture PPP (World Bank Group, 2016). Collaboration with competitors is rooted in a joint venture based on agreement, as in the case of the Korean Public Procurement Services (Choi, 2010). This is known as a co-opetition strategy, where mutually beneficial strategies with different objectives can be strengthened between competitors (Song, 2003). The board of directors strategy is also employed, referring to the role of government

departments and agencies, such as the Ministry of Environment, Water and Agriculture, which manages the national strategic reserves for water and grains in Saudi Arabia. In addition, they offer different programmes to support investors in certain types of products, rice being one of them (MEWA, 2022). Saudi's Food and Drug Authority was responsible for localising the insulin industry under the supervision of the Ministry of Health (SDFA, 2023), and petroleum strategic reserves are under the supervision of the Ministry of Energy (Al-Naimi, 2006). Political action can be clearly recognised in government initiatives and support for different policies and programmes, such as public campaigns, government subsidies, building diplomatic relationships with other governments, monitoring and supervising the local market and ensuring its stability, educating society and directing citizens to the required industries, and investing in R&D. Finally, there is executive succession on a national level, represented by the smooth process of handing over power as much as the process safe and clear as much as stable transition its which reflect the strength of the national political regime which one of its sides indicate the extent of risk combined with supply flow for critical products either in importing or to exporting required products (Zsidisin & Henke, 2019).

Combining these strategies with the principle of the purchasing portfolio improves the management of critical intermediate and final products on a national basis. These strategies can be used to move products between the quadrants of the model and position them in the most favourable one, which on the national level, is the non-critical quadrant. To illustrate, on an organisational level, leverage is the best quadrant for organisations as it is where they can exploit their power over suppliers due to the product's position (Rachman, 2019). However, this study has classified rice as a leveraged product in Saudi Arabia, which is acceptable, but what if insulin moves to the leverage quadrant? This would be considered a bad indication as it would signify that

the population was in danger, relying heavily on insulin due to unhealthy lifestyles or behaviours. Therefore, government intervention is mandatory at this stage through policies and procedures that aim to push the product from the leverage to the non-critical quadrant. Once the product is classified as non-critical, it is essential to maintain and ensure the management of the supply chain, as well as the consumption behaviours and society's attitude, as any changes in the market structure affect the product's position in the matrix. In the matrix illustrated in Figure 32, the final strategic recommendations are proposed.

Leverage quadrant

- Ensure a stable supply chain by continuously assessing the supply risk and identifying any potential supply vulnerabilities, implementing corrective actions as needed,
- Monitor and maintain the management of local markets and consumption behaviour,
- Increase the awareness of society (public campaigns),
- Enhance public trust,
- Invest in R&D, and
- Develop alternative substitutes

Strategic quadrant

- Localize the industry (if possible),
- Co-opetition strategy,
- Increase the awareness of society (public campaigns),
- Educate citizens and develop their knowledge and skills for the required industry,
- Invest in R&D,
- Subsidise products,
- Invest in the supplier's country (e.g., own farmlands-PPP),
- Suppliers' diversification,
- Build a diplomatic relationship with supplying country,
- Manage and control consumption behaviour:
    - Purchasing
    - Use
    - Dispose of (recyclable)
- Develop alternative substitutes, and
- Hold a strategic reserve.

Non-critical quadrant

- Standardise the process of securing the product by:
    - Conducting regular audits to monitor local market and consumption behaviour,
    - Simplify the outsourcing process to reduce costs, and
    - Ensure a stable supply chain by continuously assessing the supply risk and implementing corrective actions as needed, identifying potential supply vulnerabilities.
- Take advantage of the product abundance (RBV theory principles)

Bottleneck quadrant

- Localize the industry (if possible),
- Build a diplomatic relationship with supplying country,
- Suppliers' diversification,
- Increase the awareness of society (public campaigns),
- Educate citizens and develop their knowledge and skills for the required industry,
- Invest in R&D,
- Manage and control consumption behaviour:
    - Purchasing
    - Use
    - Dispose of (recyclable)
- Develop alternative substitutes, and
- Hold a strategic reserve.

Figure 32: Strategic Recommendations

6.3 Research Contributions

One of the most important aspects of modern economics is ensuring the stability and growth of the economy. One tool that can help to achieve this is holding national strategic reserves of the most important products (He et al., 2018). The topic has been discussed by many scholars for certain types of products, such as critical raw materials and natural resources, for example, water, grains, and oil. There are also intermediate and final products that have a major impact on national stability if there is a shortage or disruption in their supply (e.g., rice, gasoline, semiconductors, and insulin). Therefore, it is essential to develop a model based on the supply chain perspectives that can help with sourcing and securing the availability of these types of products, the intermediate and final products, on a national basis. To the best of the researcher's knowledge, these types of products have not yet been tackled in the context of the supply chain, particularly the purchasing area. This study contributes to knowledge theoretically, empirically, and practically by developing the national classification model.

In terms of theoretical contribution, the study attempted to expand our understanding of the Resource Dependency Theory and how it can be used to manage the national strategic reserves for critical intermediate and final products. Furthermore, the study combines the Resource Dependency Theory and Portfolio Theory – purchasing model, applying them for the first time in Saudi Arabia as part of a national case study, in a new context, with managing the national strategic reserve for critical intermediate and final products. To the extent of the researcher's knowledge, no previous studies found have employed the same principles for the same context and object of this study. Furthermore, this study has added several important variables to the theory in order to explain further the phenomena and measure the criticality level of intermediate and final products

on a national basis for both supply risk and PEST factors. However, it must be noted that these variables are subject to change according to the government and society's interests.

As discussed, this study has employed the Resource Dependency Theory and the Portfolio Theory – purchasing model. According to these two approaches, in the context of managing the national strategic reserves for critical intermediate and final products, on a national level, the non-critical quadrant is considered the preferable position to locate the tested product, whereas leverage is on an organizational level. Consequently, the advice is to manage any product listed as a non-critical product on the national level on the basis of the Resource-Based View theory. This indicates the possibility of integrating the Resource Dependency Theory and Resource-Based View theory, utilizing the principle of a purchasing portfolio. This added newfound knowledge to the literature and also led to better management of critical intermediate and final products on the national level (discussed further in the recommendations section). In addition, this study confirmed the argument raised by Gelderman (2022) in terms of the theoretical foundation of the purchasing portfolio proposed by Kraljic (1983) in all its stages, dimensions, categories and strategic recommendations.

In terms of the empirical contribution, this study has implemented a framework that can be used to gather and analyze the data required to determine the criticality level of intermediate and final products on the national level. One of the study's outcomes is its developed instrument, i.e., a tool to measure the criticality level of intermediate and final products. Thus, this study provides an empirical framework that can be used by other scholars or decision-makers who are concerned about managing the national strategic reserve or determining the criticality level of the intermediate and final products on a national basis.

In addition, this study provides a practical roadmap for decision-makers that is built on evidence-based knowledge to manage critical intermediate and final products using the concept of a purchasing portfolio. According to the proposed mechanism, decision-makers have an opportunity to manage products and move them between the model's quadrants to mitigate the risks that might occur if there is a shortage of the product. Most of these solutions were extracted from the literature review, and the last stage of the study was the expert interviews, which justified the positioning of the products tested in this study. However, it is important to note that many of these practical solutions have been implemented in reality to manage scarce products, such as critical raw materials on a national level which supports the practical side of this study, as illustrated in the discussion section (6.2). However, to the best of the researcher's knowledge, this study is the first to link these strategies with the purchasing portfolio quadrants to manage these types of products on a national basis, and this approach could be adopted for different contexts (types of products) in different environments (nations).

Finally, this study agrees with other purchasing studies such as Alhammadi (2019), Choi (2010), Grandia and Meehan (2017), Hinson and McCue (2004), McCrudden (2004), and McCue and Johnson (2010) on the important role of public procurement as a gatekeeper for managing national resources on a level broader than the organizational level, such as on a national basis. By determining the quadrant position of intermediate and final products, using the approach proposed in this study, the national classification matrix, policymakers will be able to better manage products and mitigate the potential risks to their supply that might occur.

6.4 Research Limitations and Recommendations

Regarding the limitations of this study and recommendations for future study, this research does not consider any type of product related to military purposes. It focuses on the following intermediate and final products: agricultural products (the cereals family, such as rice and wheat); energy products (gasoline and diesel); essential pharmaceutical products (insulin); and tangible technology products (semiconductors) (PPEU, 2008). The qualitative research approach resulted in comprehensive measurement variables that could be applied in different sectors; however, due to the combination of four different sectors in this study, the quantitative research determined nineteen variables, the most applicable variables for all the combined sectors, and it excluded other variables (e.g., the availability of raw materials). Therefore, it is highly recommended that a study be conducted focusing on one type of product, such as the cereal family or energy products. In addition, the study was conducted in one country, Saudi Arabia, from April 2021 to May 2023. Therefore, it is highly recommended that a similar study be conducted in a different country to confirm the validity of these variables in a different environment.

When testing the reliability of the instrument, the number of valid cases was 43, and the number of excluded cases was 109. This was due to the fact that the questions asking the experts about their level of satisfaction with the availability and implementation of policies and procedures were taken by them to refer to the recyclability of the products being studied. Semiconductors are considered to be recyclable, whereas gasoline and insulin are not. Therefore, the number of excluded cases was higher than that of valid cases, which weakens the generalizability of the results (Dong & Peng, 2013). When these two questions were removed, the number of valid cases became higher (118) than the number of excluded cases (34), which is within the acceptable range

(Dong & Peng, 2013). Learning from this, it is recommended that future researchers differentiate between recyclable and non-recyclable products to reduce the excluded cases (question no. 8).

In terms of the quantitative research sample size, although those 152 participants were an acceptable sample size for conducting factor analysis (de Winter, Dodou, & Wieringa, 2009; Field, 2013; Pallant, 2020), it is recommended that the number of participants be increased to 300. However, this might be very difficult and time-consuming as this type of study requires the involvement of experts who are aware of the current status of the product being tested with regard to their sourcing and impact on PEST factors. However, two statistical techniques were applied in this research to validate the result quantitively: item-total correlation and factor analysis. Moreover, it's essential to acknowledge that factor analysis is complex and relies heavily on the researcher's judgment, which could introduce subjectivity. The Likert scale, while offering a gradient of responses, can lack specificity. The Pearson correlation measures only linear relationships between variables, non-linear relationships will be overlooked. In addition, one of the conditions that had to be met in order to participate in this study was to have over 5 years of experience in their certain field. This eliminates newer experts who might have innovative or different perspectives. Finally, although the technique of Delphi considers one of the most important validation techniques in qualitative studies as stated by Yvonna and Egon (1981). However, it must be noted that the iterative nature of the Delphi technique could amplify prevailing views while diminishing outliers.

For future studies, first, it is recommended to retest the products analyzed in this study (rice, gasoline, semiconductors, and insulin) after five years and compare the results with the current findings in Saudi Arabia. That would enhance the reliability of the model as well as the effectiveness of the strategic plans pursued by the government to mitigate potential risks. It is

highly recommended that the model be applied in a different (country) using similar products. That would reflect on the model's reliability for classifying critical intermediate and final products on a national basis. It is recommended that different types of products be tested in sectors other than those tested in this research. With the multidimensional scale (MDS) technique adopted to interpret and visualize the quantitative result, there is an opportunity to adopt different mathematical formulas (e.g., TOPSIS, NEDO, SCARCE). Furthermore, it's recommended to conduct a study that aims to identify which of these techniques are more prevalent and effective and why in terms of determining the criticality level of the object being tested using the purchasing portfolio model.

The final recommendation is to develop a model based on the Resource-Based View Theory from a national perspective for intermediate and final products, which would require identifying the measurement variables for both dimensions. Through the adoption of the purchasing portfolio model on a national level, an integration opportunity arises between the Resource Dependency Theory and the Resource-Based View. This overlapping can be seen in the non-critical quadrant, as shown in Figure 33. To illustrate further, according to the resource dependency theory, gasoline in Saudi Arabia should be listed as a non-critical product, in line with the theory principles; however, as the Resource-Based View utilizes different factors, the result with this theory might be completely different. Therefore, this study took the opportunity to test rice, gasoline, semiconductors, and insulin on a national basis in Saudi Arabia, using the principles of the Resource-Based View. This result confirmed that combining the theories led to better national resources management.

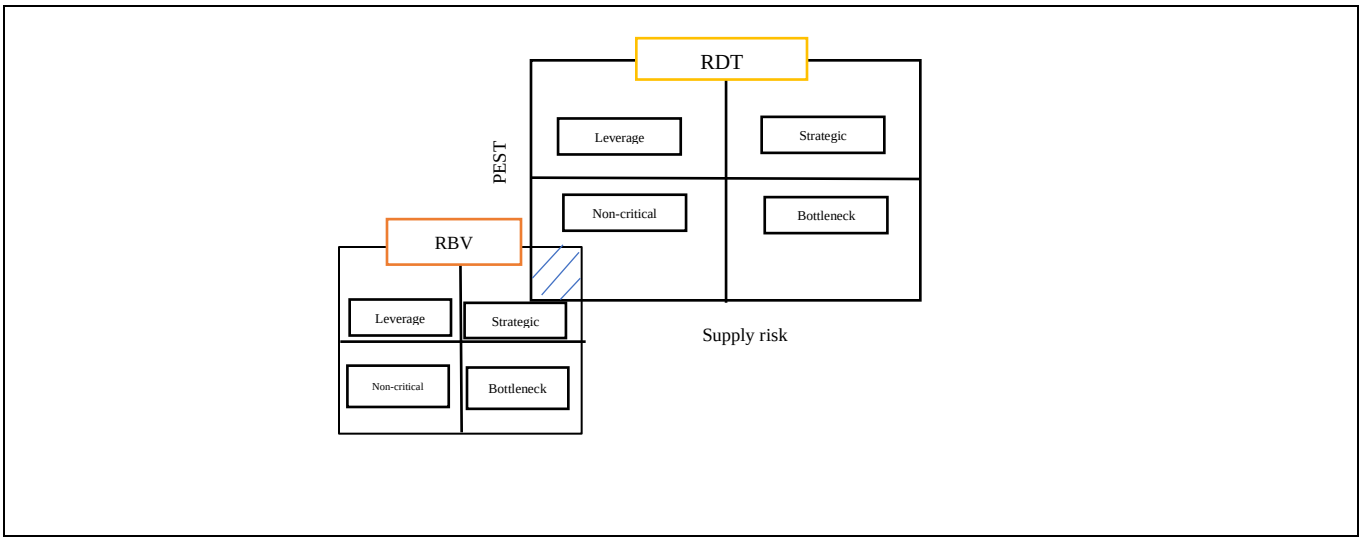

Figure 33: RBV Gateway

Finally, when reviewing the literature, it was noted that there was a lack of studies conducted in Saudi Arabia that used the purchasing portfolio model in both the public and private sectors. There is little literature, for example, on the semiconductor supply chain in Saudi Arabia. In fact, in general, there was a dearth of studies that investigated managing national strategic reserves in Saudi Arabia and in other countries.

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Appendix

Appendix A

A Model to Manage the National Strategic Reserve

Questionnaire

The online version can be revealed by clicking (here)

Agreement and Privacy Statement

Dear participant,

You are invited to contribute to a project being conducted at Dublin City University (DCUREC/2021/054), funded by the government of Saudi Arabia (IRJU1901). This document describes the project in simple/plain language. Please read the content section below carefully and make sure that you fully understand it before deciding to participate in this study. If there are any questions or concerns, please do not hesitate to ask the investigator of this research.

This study aims to measure the importance level of the product on the national level by investigating the interrelation between the flow of supply risk influence on the political, economic, sociocultural, and technology. The primary analysis of the literature review showed that there is no study to determine the importance of major products at the national level in Saudi Arabia. The entire report of the study will be available at the end of the PhD process.

What are the risks or benefits of taking part in this research study?

There is no specific risk in participating in this study. The participant is free to withdraw at any time or point of the research process. All data gathered will be strictly kept anonymous and confidential. The study explores an important issue associated with national strategic products. Its hoped that the study will significantly contribute to the national supply chain, a profession in the public and private sector, and all participants involved in this research project will benefit from the knowledge.

What will happen to the information you provide?

The information you provide might be critical to understanding elements needing in-depth investigations. The information might be used to write academic publications, conference papers, and reports. Data management will be conducted in accordance with the General Data Protection Regulation (GDPR) principles. Although no personal data will be collected, the researcher will ensure that any data collected is accurate, that the data is minimized, collected only for the purpose of this specific research project, and is stored only for the duration of the time taken to complete this research project. The researcher will ensure that any data collected is only processed for the specific purpose of this study. Data will be securely stored on a password-protected computer, and personal details will not be disclosed to any third-party entities. All the information you provide will be confidential. Please note that with all efforts will be provided to ensure the protection of data collected, participants are advised that data will be protected under the legal limitations of the law. In accordance, data may be subject to subpoena or freedom of information claim. The collected personal details will be deleted within six months of completing the research project. Data collected in this research will not be accompanied by any personal identification information. There will not be a risk or harm affecting the participants of this study. If you need further data protection information, refer to the DCU Data Protection Officer – Mr Martin Ward (data.protection@dcu.ie Ph: 7005118 / 7008257).

Involvement in the research project is voluntary.

Any participation in the study is entirely optional, and any participant has the right to withdraw consent, which requires no reason to be given. You have the right:

- To withdraw from the study at any time or at any point in the research process
- To have any unprocessed data withdrawn and destroyed, providing that doing this has no effect or risk for the participant
- To have any questions answered during the research process

If you need any further information, please do not hesitate to contact either the supervisors or the principal investigator:

- Researcher:AimanFadil(email:aiman.fadil2@mail.dcu.ie|Ph:+353870653311/+966560077429)
- Supervisor: Dr Paul Davis: (email: paul.davis@dcu.ie | Ph: +35317005627)
- Supervisor: Dr John Geraghty: (email: john.geraghty@dcu.ie | Ph: +35317007739)
- Supervisor (In Saudi Arabia): Dr Saleh L. Alghamdi (email: slalghamdi@uj.edu.sa | Ph: +966561100104)

Accepting participation in this study indicates that you have read and understood the purpose of the study and are willing to participate in this research.

If participants have concerns about this study and wish to contact an independent person, please contact:

The Secretary, Dublin City University Research Ethics Committee, c/o Research and Innovation Support, Dublin City University, Dublin 9. Tel 01-7008000, e-mail rec@dcu.ie

Table 52: Study Questionnaire

SN	Question	Indicators			
1	**Gender**	Male	Female		
2	**Level of education you have completed**	Bachelor's degree or less	Master's degree	Doctoral Degree	
3	**Work experience**	Less than 7	7 to less than 10	More than 10 years	
4	**Experience background**	Practical (A person who has practical knowledge by working in the field like traders, suppliers, farmers, producers, staff ... etc.)		Theoretical (A person who has academic knowledge or is interested in the field/product by reading, researching … etc.)	Both
5	**In Saudi Arabia, (From 1 to 7) how available are/is the:**				
	Scale used: Extremely scarce (1) … Extremely available (7)				
	NCMX01	Raw materials needed for producing gasoline?			
	NCMX02	Feasible alternatives for gasoline?			
	NCMX03	Qualified personnel in gasoline?			
	NCMX05 (A)	Local gasoline producers?			
	NCMX06	Gasoline investors?			
	NCMX04	Strategic reserves of gasoline?			
	NCMX08	Scientific research centers for gasoline?			
6	**In Saudi Arabia, (From 1 to 7) how satisfied are you with:**				

Table 52 (continued)

	Scale used: Very dissatisfied (1) …Very satisfied (7)	
	NCMX14	The overall logistic services for gasoline (harbor, warehouses, distribution channels, etc.)?
	NCMX16	The accuracy of available data for forecasting the gasoline demand?
	NCMX21 (A)	The consumption behavior by gasoline users regarding product usage and disposal methods -if applicable?
	NCMX21 (B)	The availability of policies and procedures to manage the consumption behavior of gasoline consumers (e.g., increase the price, impose fine, educate the society about optimal use of product… etc.)?
	NCMX21 (C)	The implementation of policies and procedures to manage the consumption behavior of gasoline users?
7	**Is gasoline considered recyclable?**	
	Yes	No (go to Q.9)
8	**If yes, In Saudi Arabia (from 1 to 7), how satisfied are you with:**	
	Scale used: Very dissatisfied (1) … Very satisfied (7)	
	NCMX21(D)	Availability of policies and procedures to recycle gasoline?
	NCMX21 (E)	Implementation of policies and procedures to recycle gasoline?
9	**In Saudi Arabia (From 1 to 7), how easy is it to:**	
	Scale used: Not easy at all (1) …Very easy (7)	
	NCMX18 (A)	Produce gasoline?
	NCMX18 (B)	Store gasoline?
10	**In Saudi Arabia, (From 1 to 7) to what extent:**	
	Scale used: No affect at all (1) … Extremely affected (7)	
	NCMX24	Gasoline operational activities cost the government?
11	**To satisfy the local needs, does the market of Saudi Arabia rely on external suppliers for rice?**	
	Yes	No (go to Q.14)
12	**If gasoline was produced outside Saudi Arabia, (From 1 to 7) how available are/is the:**	
	Scale used: Extremely scarce (1) … Extremely available (7)	
	NCMX05 (B)	Global gasoline supplier?
13	**If gasoline was outsourced (From 1 to 7):**	
	Scale used: Extremely low (1) … Extremely high (7)	
	NCMX07	How does the market of Saudi Arabia rely on external gasoline suppliers?
	NCMX27	What is the capacity limit of the supplier to export gasoline to Saudi Arabia (Production limit)?
	NCMX29	How flexible is the trade agreement between Saudi Arabia and the most reliable gasoline supplier country?
	NCMX12	How vulnerable is the flow of gasoline supply to any of the following events: adverse weather, natural disaster, war, pandemic, climate change, or cyberattack?
	NCMX13	How stable is the political regime of gasoline producer countries in general?
	NCMX15	How do policies and procedures at the supplier's country negatively affect the supply of gasoline to Saudi Arabia (Quotas and restrictions in the supplier's country)?
	NCMX26	How the supplier's gasoline market condition is subject to one of the following practices: monopoly, cartels… etc.?

Table 52 (continued)

	NCMX23	How tough is the global competition of gasoline?
14	**Hypothetically, if there were a lack of gasoline from local markets in Saudi Arabia (From 1 to 7), to what extent would you expect the effect to be on the:**	
	Scale used: No affect at all (1) … Extremely affected (7)	
	NCMY01	Nation's stability and security?
	NCMY04	Gasoline's demand?
	NCMY03	Gasoline's price stability?
	NCMY06	Return on government investment for businesses related to gasoline projects?
	NCMY02	National macroeconomic (GDP, employment rate, interest rate, inflation…etc.)?
	NCMY05 (A)	Public projects/services that rely on gasoline?
	NCMY05 (B)	Local industries and businesses that rely on gasoline?
	NCMY07	Government expenses (subsidize, national debt, etc.)?
	NCMY08	Human life (mortality rate)?
	NCMY09	Societal attitude (purchasing habits, crime rate, antisocial activities)?
	NCMY14	Advancement of national technology and innovation?

Appendix B

Ollscoil Chathair Bhaile Átha Cliath
Dublin City University

DCU

Alman Fadil
School of Mechanical & Manufacturing Engineering

Assist. Prof. John Geraghty
School of Mechanical & Manufacturing Engineering

Dr. Paul Davis
DCU Business School

8th April 2021

REC Reference: **DCUREC/2021/054**

Proposal Title: **Managing the Strategic Reserve at the National Level – Saudi Arabia a case study**

Applicant(s): **Alman Fadil, Assist. Prof. John Geraghty, and Dr. Paul Davis**

Dear Colleagues,

This research proposal qualifies under our Notification Procedure, as a low risk social research project. Therefore, the DCU Research Ethics Committee approves this project.

Materials used to recruit participants should state that ethical approval for this project has been obtained from the Dublin City University Research Ethics Committee.

Should substantial modifications to the research protocol be required at a later stage, a further amendment submission should be made to the REC.

Yours sincerely,

Geraldine Scanlon

Dr Geraldine Scanlon
Chairperson
DCU Research Ethics Committee

DCU
Research & Innovation

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Appendix C

Study Finding

A Mixed-Method Approach to Develop a Model to Manage the National Strategic Reserve for Critical Intermediate and Final Products in Saudi Arabia

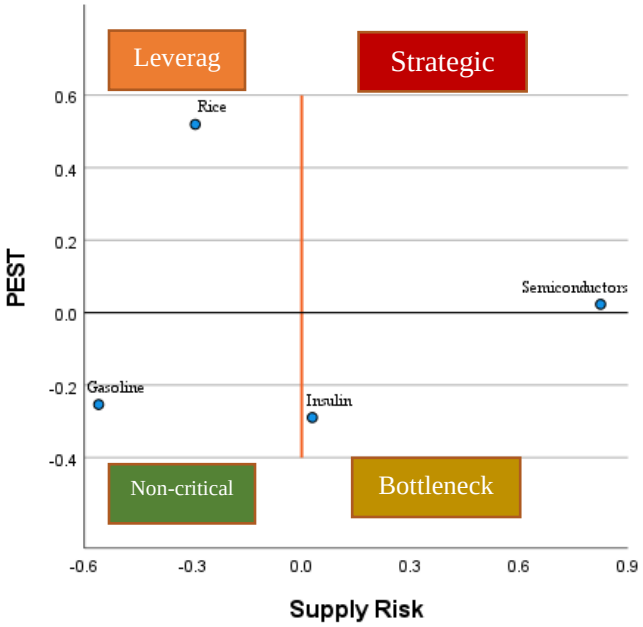
(Final Step: Verifying the result by Expert)

This study aims to identify the criticality level of the product that needs to be reserved strategically on the national level. Four products were tested on a national basis in Saudi Arabia. They are insulin, gasoline, rice, and semiconductors. This study implemented a model called the "purchasing portfolio model", which consists of two dimensions (PEST factors and Supply risk factors) formulated in four quadrants:

** PEST stands for political, economic, sociocultural, and technology*

1. **The strategic quadrant** occurs when the level of PEST and supply risk impact is high. Any products classified inside this quadrant usually have a very limited supply source. At the same time, the absence of a product has a high level of impact on politics, the economy, the sociocultural, or technology.
2. **The bottleneck quadrant** occurs when the level of supply risk is high, and the PEST impact is low. It represents a relatively limited value in terms of politics, economy, sociocultural, and technology but is vulnerable with regard to supply.
3. **The leverage quadrant** occurs when the level of PEST impact is high and the level of supply risk is low. This is the most favourable quadrant where the risk in supply flow is low due to either the local availability of the product or the number of available suppliers all over the world.
4. **Non-critical quadrant** occurs when the level of both dimensions is low. At this quadrant, the product is critical; however, there won't be a significant issue affecting PEST factors, in particular during the short time of absence.

A questionnaire was distributed among a high level of expertise in Saudi Arabia in four different sectors related to the products being tested. The result of expert's feedback was analyzed statistically and visualized on the following matrix:



(Discussion questions) Having regard to the result:

1. Do you agree or disagree with the (rice, gasoline, semiconductors, and insulin) position in Saudi Arabia? Why?
2. What would be your advice to the decision-makers in terms of managing the future of (rice, gasoline, semiconductors, and insulin) based on the current status of the product?

Appendix D

Table 53: Academic Activities (Relevant to this Thesis)

Published Article	
Fadil, A., Davis, P., & Geraghty, J. (2023). A Mixed-Method Approach to Determine the Successful Factors Affecting the Criticality Level of Intermediate and Final Products on National Basis: A Case Study from Saudi Arabia. Sustainability, 15(6023), 6023. Retrieved from https://doi.org/10.3390/su15076023 (Fadil, Davis, & Geraghty, 2023)	
Conferences	
Research Day (DCU) – 2023	Participated
International Purchasing and Supply, Education and Research Association (IPSERA) – 2022	Paper accepted *(Working academic paper)*
International Public Procurement Conference (IPPC) – 2020	Paper accepted (C*ancelled due to the COVID-19)*
International Purchasing and Supply, Education and Research Association (IPSERA) – 2020	Paper accepted (C*ancelled due to the COVID-19)*
National Manufacturing and Supply Chain Conference and Exhibition – 2020, 2022, and 2023	Attended
Public Sector Tendering and Procurement Conference (2019)	Attended
ERIM Summer School 2020 (2 ECTS- 56 hours) – PhD course	Attended